UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION, PESTICIDES
AND TOXIC SUBSTANCES

Note to Reader
January 8, 1998

Background: As part of its effort to involve the public in the implementation of the Food Quality Protection Act of 1996 (FQPA), which is designed to ensure that the United States continues to have the safest and most abundant food supply. EPA is undertaking an effort to open public dockets on the organophosphate pesticides. These dockets will make available to all interested parties documents that were developed as part of the U.S. Environmental Protection Agency's process for making reregistration eligibility decisions and tolerance reassessments consistent with FQPA. The dockets include preliminary health assessments and, where available, ecological risk assessments conducted by EPA, rebuttals or corrections to the risk assessments submitted by chemical registrants, and the Agency's response to the registrants' submissions.

The analyses contained in this docket are preliminary in nature and represent the information available to EPA at the time they were prepared. Additional information may have been submitted to EPA which has not yet been incorporated into these analyses, and registrants or others may be developing relevant information. It's common and appropriate that new information and analyses will be used to revise and refine the evaluations contained in these dockets to make them more comprehensive and realistic. The Agency cautions against premature conclusions based on these preliminary assessments and against any use of information contained in these documents out of their full context. Throughout this process, If unacceptable risks are identified, EPA will act to reduce or eliminate the risks.

There is a 60 day comment period in which the public and all interested parties are invited to submit comments on the information in this docket. Comments should directly relate to this organophosphate and to the information and issues available in the information docket. Once the comment period closes, EPA will review all comments and revise the risk assessments, as necessary.

These preliminary risk assessments represent an early stage in the process by which EPA is evaluating the regulatory requirements applicable to existing pesticides. Through this opportunity for notice and comment, the Agency hopes to advance the openness and scientific soundness underpinning its decisions. This process is designed to assure that America continues to enjoy the safest and most abundant food supply. Through implementation of EPA's tolerance reassessment program under the Food Quality Protection Act, the food supply will become even safer. Leading health experts recommend that all people eat a wide variety of foods, including at least five servings of fruits and vegetables a day.

Note: This sheet is provided to help the reader understand how refined and developed the pesticide file is as of the date prepared, what if any changes have occurred recently, and what new information, if any, is expected to be included in the analysis before decisions are made. **It is not meant to be a summary of all current information regarding the chemical.** Rather, the sheet provides some context to better understand the substantive material in the docket (RED chapters, registrant rebuttals, Agency responses to rebuttals, etc.) for this pesticide.

Further, in some cases, differences may be noted between the RED chapters and the Agency's comprehensive reports on the hazard identification information and safety factors for all organophosphates. In these cases, information in the comprehensive reports is the most current and will, barring the submission of more data that the Agency finds useful, be used in the risk assessments.

Jack E. Housenger, Acting Director
Special Review and Reregistration Division

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[Dated July 8, 1998]

Memorandum

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Subject: Reregistration Eligibility Document for Disulfoton (D237134)

Attached to this memorandum is the EFED RED chapter for disulfoton. EFED has reviewed available studies for disulfoton and finds that there is enough information to describe the fate and effects properties of the chemical and to screen for concerns for effects on nontarget species. This transmittal memo summarizes EFED's findings and recommendations for potential mitigation, monitoring and labeling.

The risk assessment was performed by evaluating use information listed in both the BEAD LUIS report for disulfoton as well as information supplied by Bayer Corporation, the major registrant for disulfoton products.

Background

Disulfoton is an organophosphate insecticide/acaricide used on a variety of terrestrial food crops, terrestrial feed crops, and terrestrial nonfood crops. Disulfoton is formulated as 15% granules, 8% emulsifiable systemic, 95% cotton seed treatment, systemic granules (1, 2, 5, 10%), and 68% concentrate for formulating garden products. Directions regarding application intervals, number of applications and total application per year or crop cycle are not always specified by the label.

Environmental Fate Summary

Parent disulfoton has low potential mobility and is neither persistent nor volatile. Disulfoton photo degrades within 2-4 days on soil and in water under natural sunlight. Disulfoton is essentially stable to hydrolysis at 20°C, but hydrolyzes much more rapidly at 40°C.
Aerobic soil metabolism and field dissipation data indicate that the sulfoxide and sulfone degradates of disulfoton are mobile and persistent, but there is insufficient environmental fate information on the degradates to fully characterize their fate and transport.

Water Resources Summary

The fate of disulfoton in surface water and ground water, and the likely concentrations therein, cannot be modeled with a high degree of certainty since no data are available for the aerobic and anaerobic aquatic degradation rates, and anaerobic soil metabolism. The large degree of latitude available in the disulfoton labels also allows for wide variation in possible application rates, total amounts of disulfoton applied, application methods, and intervals between applications. Considering the relatively rapid rate of microbial degradation in the soil (<20 day aerobic soil metabolism half-life) and direct aquatic photolysis in surface water, parent disulfoton may degrade fairly rapidly. However, peak concentrations appear capable of being quite high, especially when high application rates are used.

Ground water and surface water monitoring data tends to confirm fairly rapid degradation, but potentially high peak values. The majority of samples had low levels (<16 µg/L) of disulfoton residues. However, there were indications of some high concentrations, which may be a reflection of how the data were reported as the disulfoton concentrations in the monitoring were not always known. This is because the detection limit was extremely high or not specified, and/or the limit of quantification was not stated or extremely high. Disulfoton concentrations were simply given as less than a value. Therefore, considerable uncertainty exists with respect to the monitoring data (especially the STORET data). Although no assessment can be made for degradates due to lack of data, limited data suggests that the degradates are more persistent (>200 days) than disulfoton, suggesting their presence in water for an longer period of time than the parent. The degradates also appear to be more mobile than the parent compound.

Surface Water:

The Tier I upper-bound estimates of disulfoton concentrations in surface water using the GENEEC screening model results in minimum peak concentration of 11.2 µg/L for spring wheat in South Dakota and a maximum of 285.4 µg/L for potatoes in Maine. The minimum and maximum 56-day concentrations were 8.7 and 221.2 µg/L for wheat and potatoes, respectively.

In the Tier II assessment, the overall upper 90% confidence bound on the estimated multiple year mean concentrations of disulfoton in a farm pond over multiple years simulated ranged from 3.08 µg/L for a single application at the maximum rate (1.00 lb ai/A) to spring wheat in South

Dakota to 43.24 µg/L for potatoes in Maine with two applications at the maximum application rate (9.39 lb ai/A). These upper 90% confidence bounds are the best values to use in cancer risk assessments as they are the best estimates of lifetime mean concentrations. Maximum, or peak, estimated concentrations of 117.0 µg/L occurred for two 9.39 lb. ai/ac applications of disulfoton to potatoes. For the other scenarios, the maximum concentrations ranged from 7.72 to 98.19 µg/L. The Tier II modeling results from PRZM/EXAMs fall within the range of concentrations for surface water reported in the STORET database (0.0 to 100 µg/L). Because in STORET many samples were listed as "actual value is known to less than given value", the maximum concentration of samples was not always known (see Appendix III). The modeling results therefore cannot be confirmed by the monitoring data.

Ground Water:

The maximum disulfoton ground water concentration predicted by the SCI-GROW model (using the maximum rate 9.39 lb. a.i./ac and 2 applications) was 0.83 µg/L.

Disulfoton Monitoring Data

The Pesticides in Ground Water Data Base (USEPA, 1992) summarizes the results of a number of ground water monitoring studies conducted which included disulfoton (and disulfoton degradates D. sulfone and D. sulfoxide). Monitoring, with no detections (limits of detections ranged from 0.01 to 6.0 µg/L), has occurred in the following states (number of wells): AL (10), CA (974), GA (76), HI (5), IN (161), ME (71), MS (120), MN (754), OK (1), OR (70), and TX (188). Disulfoton residues were detected in ground water in Virginia and Wisconsin. In Virginia, 6 of the 12 wells sampled had disulfoton detections ranging from 0.04 to 2.87 µg/L. In Wisconsin, 14 of 26 wells sampled had disulfoton residues ranging from 4.0 to 100.0 µg/L. One hundred twenty wells were analyzed in MS for degradates D. sulfone and D. sulfoxide and 188 wells were analyzed in TX for D. sulfone. Limits of detection were 3.80 and 1.90 µg/L for the sulfone and sulfoxide degrade, respectively, in MS. There were no degradates reported in these samples.

Several limitations for the monitoring data should be noted. These limitations include: the use of different limit of detections between studies, lack of information concerning disulfoton use around sampling sites, and lack of data concerning the hydrogeology of the study sites.

Toxicity Summary

The available acute toxicity data on the TGAI indicate that disulfoton is: highly to very highly toxic to birds on an acute oral basis (LD_{50} = 3.2 to 39 mg/kg); moderately toxic to birds on a dietary basis (LC_{50} = 510 to 622 ppm); highly toxic to mammals on an acute oral basis (LD_{50} = 1.9 to 15 mg/kg); highly toxic to bees (LD_{50} = 4.1 µg/bee); very highly toxic to slightly toxic to freshwater fish (LC_{50} = 39 to 7,200 ppb); very highly toxic to freshwater invertebrates (LC_{50} = 3.9 to 52 ppb); highly toxic to marine/estuarine fish (LC_{50} = 520 ppb) and very highly toxic to marine/estuarine invertebrates (LC_{50} or EC_{50} = 15 to 900 ppb). Acute toxicity for the sulfone degradate indicate that it is highly toxic to birds on an acute oral basis (LD_{50} =18 mg/kg), highly toxic to birds on a dietary basis (LC_{50} =558 to 622 ppm), highly toxic to mammals on an acute oral basis (LD_{50} =11.24 mg/kg), very highly toxic to bees (LD_{50} =0.96μg/bee), highly toxic to moderately toxic to freshwater fish (LC_{50} = 112 to >9,200 ppb), very highly toxic to freshwater invertebrates (LC_{50} = 35.2 ppb), and moderately toxic to marine/estuarine fish (LC_{50} =1,060 ppb). The sulfoxide metabolite is very highly toxic to birds on an acute oral basis (LD_{50} = 9.2 mg/kg); very highly toxic to highly toxic to birds on a dietary basis (LC_{50} = 456 to 823 ppm); highly toxic to bees (LD_{50} = 1.11 µg/bee); highly toxic to slightly toxic to freshwater fish (LC_{50} = 188 to 60,300 ppb); very highly toxic to freshwater invertebrates (LC_{50} = 64 ppb); and slightly toxic to marine/estuarine fish (LC_{50} = 11,300 ppb).

Chronic toxicity studies established the following NOEC values: 37 ppm for birds, 0.8 ppm for small mammals, 220 ppb for freshwater fish (2.3 ppb for bluegill sunfish, using the factor of chronic to acute values for the rainbow trout), 0.037 ppb for freshwater invertebrates, 16.2 ppb for marine/estuarine fish early life-stage, 0.96 ppb for marine/estuarine fish for life-cycle, and 2.35 ppb for marine/estuarine invertebrates.

Risk Assessment Summary

Birds: The overall **acute** risk to birds is high for most of the label application rates and methods for the liquid formulations of disulfoton. Even the lowest application rate (0.5 lb ai/A) still exceeds the restricted use level of concern when it is applied 3 times per year as permitted by the label. The granular formulations of disulfoton also present high acute risk to birds, especially from banded applications. In-furrow applications present somewhat less risk to birds due to the lowered exposure to the actual granules, but the high-risk level of concern is still exceeded. Since disulfoton is systemic, birds can still be exposed to toxic levels of the pesticide in plant tissues and in insects that feed on the plant tissues. One bird-kill incident was found to be caused by this route of exposure (L. Lyon, SETAC, 1997). The sulfone and sulfoxide degradates of disulfoton are persistent (half-lives of up to 367 days), and exhibit comparable avian acute toxicity to parent disulfoton. Because of this, there is the potential for adverse effects to birds for a prolonged period of time following even a single application. Several incident reports of bird kills support the presumption of acute risk to birds. Terrestrial field testing also confirmed the potential of disulfoton to kill birds in the field.

The range of RQs for **chronic** exposure exceed the LOC in all types of food items for nearly all labeled application rates. Residues in seeds/large insects are the lowest, and the chronic LOC was not exceeded by seed/large insect residues for multiple applications at or below 1 lb ai/A or single applications at or below 2 lb ai/A. As with the acute risk, the chronic risk is increased by the persistence of the sulfone and sulfoxide degradates. Since many of the applications of disulfoton occur in the spring, overlapping the breeding season for most bird species, there is the potential for significant reproductive impacts

Mammals: The overall **acute** risk to mammals is expected to be high. All modeled application rates and methods exceed the high risk acute level of concern for mammals, regardless of the mammals' size and diet composition. Since disulfoton is a systemic pesticide, the granular formulations can result in exposure through food items due to uptake by the plant tissues in addition to direct exposure to any unincorporated granules. Applications of the liquid formulations of disulfoton also result in direct exposure and exposure in food items. The persistent sulfone and sulfoxide degradates are also toxic to mammals, thereby increasing the potential risk from the application of disulfoton. The Incident Data System (IDS) contains numerous domestic animal injury and death incidents, including deaths of large mammals such as horses and cattle. Small mammal mortality also occurred during terrestrial field testing of disulfoton on potatoes, confirming the presumption of acute risk to mammals.

Mammalian chronic risk quotients are exceeded for all registered application rates, regardless of single or multiple applications. Potatoes present the highest risk, due to the high application rate. The LOC is exceeded by 71 to 819 times in all categories. The persistence of the sulfone and sulfoxide degradates increases the likelihood of chronic risk to mammals.

Non-target Insects: Disulfoton and its sulfoxide and sulfone degradates are very highly toxic to bees, so it is likely that bees, as well as other non-target and beneficial insects, would be harmed if exposed to disulfoton in the field.

Freshwater Fish: The overall **acute** risk to freshwater fish is expected to be high. Three of the five crop scenarios modeled resulted in exceedance of the high acute risk level of concern, with the remaining two scenarios exceeding the restricted use and endangered species levels of concern. Several kills of freshwater fish have occurred from applications of disulfoton to different crops, from registered uses as well as from misuse. There is, however, a large amount of variation in freshwater fish species' sensitivity to disulfoton, as evidenced in the toxicity data table. There are also incident reports of several fish kills from disulfoton use, supporting the presumption of acute risk to fish.

Chronic risk to freshwater fish is expected from the use of disulfoton. The single freshwater fish species (rainbow trout) for which chronic toxicity data was available demonstrates significantly less sensitivity to disulfoton than several other species (bluegill sunfish, bass, guppy). Therefore, an estimated chronic NOEC value was calculated using the chronic to acute ratio for the rainbow trout. A full description of this method is presented in the RED chapter.

Freshwater Invertebrates: The overall **acute** risk to freshwater invertebrates is expected to be high. All the modeled crop scenarios exceeded the high risk level of concern by as much as 9 times. Again, the risk is further increased due to the toxicity and persistence of the degradates of disulfoton.

Chronic risk to freshwater invertebrates is expected from the use of disulfoton. All of the modeled crop scenarios greatly exceeded the high risk level of concern, sometimes by a factor of several thousand. Invertebrate life-cycle testing with disulfoton shows that it impacts reproductive parameters (number of young produced by adults) in addition to survival and growth.

Estuarine and Marine Fish: The overall **acute** risk to estuarine and marine fish is not expected to be high; however, the endangered species level of concern was exceeded by several of the modeled crop scenarios (cotton, potatoes and wheat). As noted above, there can be substantial species differences in sensitivity to disulfoton. Therefore, it is possible that the single marine/estuarine fish species tested (Sheepshead minnow) does not fully represent the true range of sensitivity found in a marine or estuarine ecosystem, and this assessment may therefore underestimate the true risk to marine/estuarine fish.

Chronic risk to estuarine and marine fish is expected from the use of disulfoton. Both early life-stage and full life-cycle testing demonstrated a variety of effects at low levels of disulfoton. Risk quotients based on the early life-stage toxicity endpoint exceeded the level of concern for cotton, potatoes and tobacco, and risk quotients based on the life-cycle toxicity endpoint exceeded the level of concern for all modeled scenarios.

Estuarine and Marine Invertebrates: The overall **acute** risk to marine and estuarine invertebrates is expected to be high. Three of the five modeled scenarios (cotton, potatoes, and tobacco) resulted in exceedance of the estuarine/marine invertebrate high risk level of concern.

Chronic risk to marine/estuarine invertebrates is expected. All of the modeled crop scenarios exceeded the chronic level of concern, by as much as 45 times in some cases.

Plants: Terrestrial and aquatic plant testing is required for disulfoton, due to the phytotoxicity statements on the label. No plant toxicity data was available at the time of this risk assessment, however, so no statement can be made regarding the risk to terrestrial or aquatic nontarget plants from the use of disulfoton.

Recommendations

Data Gaps:

The following environmental fate requirements are not satisfied for disulfoton:

- 162-3: Anaerobic Aquatic Metabolism
- 162-4: Aerobic Aquatic Metabolism

Additionally, there is little environmental fate data available for the sulfone and sulfoxide degradates. Data on the fate of these degradates in soil and water would allow additional characterization of the risks they present to nontarget organisms.

The following ecological effects data requirements are not satisfied for disulfoton:

- 122-1: Tier I Terrestrial Plant Testing

122-2: Tier I Aquatic Plant Testing
(123-1 and 123-2, Tier II testing, are reserved pending the results of Tier I testing).

Mitigation: The use of disulfoton at single application rates of 1.0 lb ai/A and greater, and multiple application rates of 0.5 lb ai/A and greater, poses a high acute risk to birds, mammals, fish, and aquatic invertebrates, as well as to nontarget insects. EFED believes that amending label rates to the lowest efficacious rate as a maximum, as well as restricting the number of applications per year and lengthening the application interval, would reduce acute risk to terrestrial and aquatic organisms. Requiring in-furrow applications wherever feasible, and eliminating banded applications of granular disulfoton with narrow row spacing, would also reduce the risk to nontarget organisms, especially birds and mammals. Care must be taken, however, so that the likelihood of disulfoton or its degradates leaching to ground water is not increased by these application methods. Eliminating aerial applications of disulfoton and imposing buffer strips around aquatic habitats would reduce the risk to aquatic organisms. Risk to bees and other nontarget insects could be lowered by not applying disulfoton when the insects are likely to be visiting the area. The following information may be helpful in attempting to mitigate the adverse effects of disulfoton on non-target insects:

> The time of day an insecticide is applied directly impacts its risk to foraging bees. Bee kills are often 2-4 times greater when applications are made in early morning as when they are made in late evenings.
>
> Disulfoton should not be applied to crops in bloom and when adjacent crops, interplants, and weeds in orchard cover crops or field edges are flowering. To reduce the risk to bees, flowering weeds should be eliminated from orchard cover crops or field edges. This is especially important when there is an abundance of pollen and nectar plants in the area and bees may fly for several miles in search of flowers.
>
> The potential risk to bees is greatest from aerial applications. Spray drift off the target areas causes most bee kills. Small pesticide particles in the air blown into blooming crops or weeds are a major factor in bee poisoning. Ground sprays are generally considered safer than aerial applications because there will be less drift and smaller areas are treated at one time. Johansen also recommends that during aerial applications, the aircraft should not be turned, nor the materials transported back and forth across blossoming fields. (Johansen, Carl, A. And D.F. Mayer, N.D. Pollinator Protection, A Bee & Pesticide Handbook, N.P.)

<u>Labeling</u>

Manufacturing-Use Products

"This pesticide is extremely toxic to birds, mammals and aquatic invertebrates. Do not discharge effluent containing this product into lakes, streams, ponds, estuaries, oceans, or public waters unless this product is specifically identified and addressed in an NPDES permit. do not discharge effluent containing this product to sewer systems without previously notifying the sewage treatment plant authority. For guidance, contact your State Water Board or Regional Office of the EPA."

End-use Products

High toxicity statement: "This pesticide is extremely toxic to birds, mammals and aquatic invertebrates. Do not apply directly to water, or to areas where surface water is present or to intertidal areas below the mean high-water mark. Drift and runoff may be hazardous to aquatic organisms in neighboring areas. Do not contaminate water when disposing of equipment washwater or rinsate."

Disulfoton residue detections in ground water range from 0.04 to 100 ppb; detections are up to 300 times the Health Advisory (0.3 ppb). There is a high potential for degradates to contaminate ground water. Because disulfoton degradates are persistent, apparently mobile, and parent disulfoton has been found in ground water, a ground water label advisory is required. The following label language is appropriate: "This chemical is known to leach through soil into ground water under certain conditions as a result of label use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground-water contamination."

Disulfoton Bee Mitigation - Suggested Precautionary Label Language:

> "This product is toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product if bees are visiting the treatment area.

Spray Drift

Since disulfoton can be applied aerially, current cautionary labeling for the spray drift of aerially applied pesticides must be used.

Table of Contents

1. Use Characterization for Disulfoton

Disulfoton is a systemic organophosphate insecticide, acaracide (miticide) registered for use to control aphids, thrips, mealybugs, other sucking insects, and spider mites on a variety of terrestrial food crops (coffee, peppers, broccoli, brussels sprouts, cabbage, cauliflower, lettuce, spinach, asparagus, pecan, radish, and raspberries), terrestrial food and feed crops (tomato, barley, corn, oats, triticale, wheat, cotton, peanut, peas, sorghum, soybeans, potatoes, beans, and lentils), terrestrial feed crops (bermudagrass, and alfalfa), and terrestrial nonfood crops (christmas tree plantations, ornamentals, and non-bearing fruit). The total use of disulfoton for 1997 was approximately 1.7 million lbs ai. Cotton has the greatest use of disulfoton (420,000-840,000 lb ai/yr), accounting for 61% of the disulfoton market. Wheat has the next largest percentage of the market, at 16% (180,000-354,000 lb ai/yr). The largest use state is California (16% of the market, 272,000 lb ai/yr), followed by Louisiana (11% of the market, 187,000 lb ai/yr). Rankings of disulfoton usage by crop and by state are provided in Appendix I.

Disulfoton is formulated as 15% granules, 8% emulsifiable systemic, 95% cotton seed treatment, systemic granules (1, 2, 5, 10%), and 68% concentrate for formulating garden products. Applications are generally soil applied: in-furrow, broadcast, or row treatment followed by 2-3 inch soil incorporation. It can also be applied as a foliar treatment and in irrigation water. Cotton seeds can also be directly treated and planted. Disulfoton can be applied in multiple applications, typically up to three, at intervals from 7 to 21 days depending upon the crop. Application rates range from 0.5 to 9.39 lb ai/A.

2. Exposure Characterization

A. Chemical Profile

1. Common name: disulfoton
2. Chemical name: O,O'-diethyl-S-[2-ethylthio)ethyl]phosphorothioate
3. Trade Names: DI-Syston
4. Physical/Chemical properties:

Molecular formula: $C_8H_{18}0_2PS_3$
Molecular weight: 274.39
Physical state: colorless liquid, specific grav. 1.144 a 20° C.
Henry's Law Constant: 2.60E-6 Atm. M3/Mol (measured)
Boiling point: 62° C at 0.01 mmHg
Vapor pressure: (20° C) = 1.8 X 10^{-4} mmHg
Solubility: in water at 20° C= 25 ppm; miscible in n-hexane, dichloromethane, 2-propanol, toluene

B. Environmental Fate Assessment

I. Environmental Fate and Chemistry Data

The environmental fate and chemistry data base for disulfoton is incomplete for the parent compound. Fate data are not available for the degradation products. The major routes of dissipation are microbial degradation in an aerobic soil and aqueous photolysis and soil photolysis. Data are unavailable for anaerobic soil conditions and the aquatic environment. Disulfoton is stable to hydrolysis at 20°C at the three pH values tested but is influenced by temperature as hydrolysis is fairly rapid at 40°C.   The overall results of these mechanisms of dissipation appear to indicate that disulfoton has low to moderate persistence in the environment. Limited data suggests that the degradates are much more persistent. The individual studies are summarized below.

Hydrolysis (161-1)

The primary hydrolysis products were the disulfoton oxygen analog (POS) at pH 4, a mixture of des-ethyl disulfoton metabolites of which the major one is des-ethyl POSO2 at pH 7 and a product obtained at pH 9 which converted to 2-2- (ethylsulfonyl) ethane sulfonic acid upon treatment with potassium permanganate. The reported hydrolysis half-lives are 1174 days, 323 days, and 231 days in sterile aqueous buffered solutions at pH's 4, 7, and 9, respectively, for a 30 day study. Consequently, disulfoton is essentially stable to abiotic degradation at 20°C. At 40°C, the half-lives were 30, 23.2, and 22.7 days at pH 4, 7, and 9, respectively. The hydrolysis guideline requirement (161-1) is fulfilled (MRID 00143405).

Photodegradation in water (161-2)

Disulfoton degrades rapidly under aqueous photolysis. The half-life for aqueous photolysis (corrected for the dark control) is 3.87 days in a pH 5 buffered solution exposed to natural sunlight (Latitude 38.05 N; Longitude 84.30 W; October 5-15. 1987; average temperature 19.4+-2.08^{C}). For the purpose of modeling (in the water body), disulfoton the water photolysis rate was considered. Disulfoton sulfoxide was the major degradation product. Control (dark) samples degraded with a half-life of > 300 hours. Both reactions followed zero-order kinetics. The photodegradation in water guideline requirement (161-2) is fulfilled (MRID 40471102).

Photodegradation on soil (161-3)

The half-life of disulfoton was 2.4 days on sandy loam soil plates exposed to natural sunlight. The primary photoproduct was disulfoton sulfoxide in irradiated and dark samples. Less than 10% disulfoton oxygen analog sulfoxide and disulfoton sulfone were detected in the light exposed samples after two days of irradiation. MRID 40789701 was rejected on 8/23/89 since the proportion of metabolites formed was not presented in the study report. The registrant provided this information in a letter dated 2/11/92. The photodegradation on soil (161-3) guideline requirement is fulfilled (MRID 40471103).

Aerobic soil metabolism (162-1)

The aerobic half-life was 15.6 days; however, the reaction did not follow first-order kinetics. Less than 20% of the amount applied remained 7 days after treatment; <3% remained 60 days after treatment. The major degradates are the sulfoxide (58.7%) at 7 days, and sulfone (72%) at 90 days. At the end of the study (367 days), the sulfone was present at 35% of the applied amount, and the sulfoxide at 2% of the applied amount. Except for the sulfone and sulfoxide degradates, residues were not detectable at 367 days. The aerobic soil metabolism guideline requirement (162-1) is fulfilled (MRID 43800101). Two additional aerobic soil metabolism studies (MRIDs 40042201; 41585101) submitted by the registrant, which were determine to be supplemental studies by EFED, also provided additional information which was considered in modeling. These studies had estimated aerobic half-lives of 2.4 and 1.9 days, respectively.

Anaerobic aquatic metabolism (162-3)

This study (MRID 43042503) cannot be used to fulfill data requirement 162-3. Material balances were too low, declining from 106% immediately post-treatment to 78.7% at 202 days. Only 65% of the intended application was available at the start of the study. The study cannot be upgraded; a new anaerobic aquatic study or an anaerobic soil metabolism study must be submitted for disulfoton.

Aerobic aquatic metabolism (162-4)

No data on aerobic aquatic metabolism of disulfoton or its metabolites have been submitted.

Mobility - Leaching and Adsorption/Desorption. (163-1)

Adsorption/desorption studies of disulfoton indicated that it is slightly mobile to somewhat mobile depending on the soil. Adsorption/desorption coefficients of various soil types are tabulated below.

Table . Average Kd and Koc Adsorption/Desorption Values for Disulfoton

	Silt Loam	Sand	Clay Loam	Sandy Loam
Kd	6.85	4.67	4.47	9.66
Koc (ads.)	449	888	386	483
Koc (des.)	629	1340	547	791

The average organic carbon normalized Freundlich Kads was estimated to be 551.5 ml/g soil carbon. The Koc model generally appears to be appropriate, since the exponents are close to 1.

In a second report, # 66792, parent Freundlich K values (7.06 to 14.29) indicate that disulfoton is adsorbed to a moderate degree which also indicates low mobility in soils. The average disyston R_f value was 0.22 on six soils which also indicates low mobility of the parent disulfoton. The correlation coefficients describing the degree of data conformity to the Freundlich equation ranged from 90.3 to 99.9%. The 1/n values for the three soils were 1.002, 0.980, and 0.975. Calculated Kocs were 641, 752, and 839. The mobility-leaching and adsorption/desorption guideline requirement (163-1) is fulfilled (MRID #443731-03 and 00145469). These data were also recorded in Bayer's 11/30/93 letter to SRRD, MRID - 430425-00 pages 3 and 4.)

Mobility - Leaching of Aged Di-Syston (163-1)

This 1986 study (Acc. # 00145470) was not conducted in accordance with acceptable guidelines, and the 1986 results were not consistent with current data using guideline studies. Recent data indicate that the degradates will leach to lower depth, but the 1986 study indicated no leaching of sulfoxide and sulfone degradates. A new column leaching study is not required, because other existing data fulfill the requirement.

Laboratory Volatility (163-2)

Disulfoton volatilized at maximum of 0.026 and 0.096 $ug/Cm^{2/}hr$ from sand soil adjusted to 25% and 75% of field capacity at 0.33 bar respectively, incubated in dark for 21 days at 25 $^{\circ}$C with an air flow of approximately 300 ml/minute. Maximum volatilization occurred within 24 hours following treatment. The vapor pressure of disulfoton was reported to be 7.2 X 10^{-5} mBar at 20 $^{\circ}$C and 1.3 X 10^{-5} mBar at 25 $^{\circ}$C. Freundlich Kads for the sand soil was determined to be 0.172. The guideline requirement for laboratory volatility (163-2) has been fulfilled (MRID 42585802)

Field Volatility (163-2)

Maximum concentration observed in air at 1 foot above ground was 22.2 ng/L. Disulfoton concentrations, after 6 hours, at the 5 foot level were not detectable. Bayer, Inc. submitted additional data, e.g., ads./des. Kds, and cloud covering on the days of the experiment. The guideline requirement for field volatility (163-2) has been fulfilled (MRID 40471105).

Terrestrial Field Dissipation (164-1)

Disulfoton applied at 8 lbs./ac dissipated with a t-1/2 of 2 - 4 days from the upper 6 inches of sand/sandy loam and loamy sand/sandy loam plots in California. Parent disulfoton was detected only in the upper 6 inches of soil; the sulfoxide and sulfone degradates were detected to a depth of 18 inches. The guideline requirement for terrestrial field dissipation (164-1) has been fulfilled (MRID 43042502).

Fish Bioaccumulation (165-4)

From 60.8 to 85.9 ppb ^{14}C residues in edible fish and 38.1 to 39.9 ppb in the inedible fish tissues were not characterized. After 14 days depuration, fillet contained 21% of the applied residues, viscera 18.1%, and whole fish 22%. Bioconcentration factors were 460X for whole fish, 700X for viscera, and 460X for fillet. Bayer submitted data, at the Agency's request, which indicated that there was no mortality and no growth during the study. The bioaccumulation guideline (165-4) has been partially fulfilled (MRID 43042501, 43060101, 40471106, and 40471107). No further bioaccumulation testing is required for parent disulfoton; however, bioaccumulation information, or at least K_{ow} determination, for the sulfone and sulfoxide degradates would be helpful for risk assessment purposes.

C. Terrestrial Exposure Assessment

For pesticides applied as a nongranular product (e.g., liquid, dust), the estimated environmental concentrations (EECs) on food items following product application are compared to LC50 values to assess risk. The predicted 0-day maximum and mean residues of a pesticide that may be expected to occur on selected avian or mammalian food items immediately following a direct single application at 1 lb ai/A are tabulated below.

Table : Estimated Environmental Concentrations on Avian and Mammalian Food Items (ppm) Following a Single Application at 1 lb ai/A)

Food Items	EEC (ppm) Predicted Maximum Residue[1]	EEC (ppm) Predicted Mean Residue[1]
Short grass	240	85
Tall grass	110	36
Broadleaf/forage plants, and small insects	135	45
Fruits, pods, seeds, and large insects	15	7

[1] Predicted maximum and mean residues are for a 1 lb ai/a application rate and are based on Hoerger and Kenaga (1972) as modified by Fletcher *et al.* (1994).

Predicted residues (EECs) resulting from multiple applications are calculated in various ways. For this assessment, maximum disulfoton EECs were calculated using Hoerger and Kenaga (1972) as modified by Fletcher *et al.* (1994). These EECs served as inputs into the FATE program. The FATE program is a first order dissipation model, i.e., the pesticide is applied repeatedly, but degrades over time from the first application to the last application. The aerobic soil half-life of 15.6 days (MRID #438001-01) was used in the model. EEC values for a variety of crops and application rates/methods are provided in the risk quotient tables in Section 4, "Ecological Risk Assessment."

D. Water Resources Assessment

I. Summary and Conclusions

This section presents an assessment of the potential to contaminate surface water and ground water from labeled uses of disulfoton. The assessment is a Tier II estimate of environmental concentrations (EECs) in surface water for disulfoton as applied to barley, cotton, potatoes, tobacco, and spring wheat, using several label application (maximum and recommended) rates and methods, using PRZM3/EXAMS2. Surface water monitoring data collected by the USGS as part of the National Water Quality Assessment (NAWQA) (Gilliom, 1995; USGS, 1997) program is also considered. The potential for disulfoton residues in ground water is assessed using the EFED ground-water concentration screening model (SCI-GROW) and the monitoring data available in EFED's Pesticides in Ground Water Data Base (PGWDB) (USEPA, 1992) and the NAWQA study (USGS, 1997). The purpose of this analysis is to estimate environmental concentrations of disulfoton in surface water bodies and ground water for use in the human health and ecological risk assessment as part of the registration process. The environmental fate data base is not complete. Limited data indicates that the degradates are much more persistent and mobile than parent disulfoton. The degradates, often as toxic as the parent compound, are not considered in this assessment due to lack of environmental fate data.

Tier I environmental concentrations (EECs) in surface water were also estimated, using the EFED GENEEC screening model, for disulfoton as applied to barley, cotton, potatoes, tobacco, and spring wheat, using several label application (maximum and recommended) rates and methods. These estimates were greater than those estimated by PRZM/EXAMS, except for the cotton scenarios, when estimates were similar for multiple years. Single year PRZM/EXAMS estimates were lower than the concentrations predicted by than GENEEC. Thus, it appeared that disulfoton was accumulating in multiple year scenarios (see later discussion). Surface and ground water monitoring data available in STORET were evaluated, but not considered due to limitations associated with high detection limits and difficulty in interpreting the data. The results of these findings (GENEEC and STORET) are presented in the Appendices III and VI, respectively .

The Tier II EEC assessment uses a single site, or multiple single sites, which represents a high-end exposure scenario from pesticide use on a particular crop or non-crop use site. The EECs for disulfoton were generated for multiple crop scenarios using PRZM3.0 (Carsel, 1997) which simulates the erosion and run-off from an agricultural field and EXAMS 2.97.5 (Burns, 1997) which simulates the fate in a surface water body. PRZM3 and EXAMS estimates for a single site, over multiple years, EECs for a 1 ha surface area, 2 m deep pond draining an adjacent 10 ha barley, cotton, potato, tobacco, or spring wheat field. Each scenario, or site, was simulated for 27 to 40 (depending on data availability) years. EFED estimated 1 in 10 year maximum peak, 4-day average, 21-day average, 60-day average, 90-day, annual average concentrations. Disulfoton (Di-Syston) formulations were based upon registered uses on the specific crops. The application rates (maximum and recommended), numbers, and intervals are listed in **Table** and environmental fate inputs are listed in **Table** . Spray drift is determined by method of pesticide application (and assumed to be 5% for aerial spray; 1% for ground spray, 0% for granular or soil incorporated applications). The Tier II PRZM/EXAMS EECs for disulfoton are listed in a **Table** . PRZM simulations were both made with the recommended and maximum application rates, maximum number of yearly applications, and the shortest recommended application interval.

The PRZM/EXAMS EECs are generated for high exposure agricultural scenarios and represent one in ten year EECs in a stagnant pond with no outlet that receives pesticide loading from an adjacent 100% cropped, 100% treated field. As such, the computer generated EECs represent conservative screening levels for ponds, lakes, and flowing water and should only be used for screening purposes. The EECs have been calculated so that in any given year, there is about a 10% probability that the maximum average concentration of that duration in that year will equal or exceed the EEC at the site. Tier II upper tenth percentile EECs are presented in **Table .**

The disulfoton scenarios **(Tables a and b)** are representative of high run-off sites for barley in the Southern Piedmont of Virginia (MLRA 136), cotton in the Southern Mississippi Valley Silty Uplands of Mississippi (MLRA 134), potatoes in the New England and Eastern New York Upland of Maine (MLRA 144A), tobacco in Southern Coastal Plain of Georgia (MLRA 133A), and spring wheat in the Rolling Till Prairie of South Dakota (MLRA 102A). The scenarios chosen are professional best judgement sites expected to produce run-off greater than would be expected at 90% of the sites where the appropriate crop is grown. Soils property data and planting date information were obtained from the PRZM Input Collator (PIC) data bases (Bird et al, 1992).

The SCI-GROW (Screening Concentration in Ground Water) screening model developed in EFED (Barrett, 1997) was used to estimate potential ground water concentrations for disulfoton parent under hydrologically vulnerable conditions. The maximum disulfoton ground water concentration predicted by the SCI-GROW using the maximum rate 9.39 lb. a.i./ac and 2 applications was 0.83 µg/L.

The fate of disulfoton in surface water and ground water and the likely concentrations cannot be modeled with a high degree of certainty, since no data are available for the aerobic and anaerobic aquatic degradation rates, and anaerobic soil metabolism. The large degree of latitude available in the disulfoton labels also allows for a wide range of possible application rates, total amounts, application methods, and intervals between applications. However, considering the relatively rapid rate of microbial degradation in the soil (<20 day aerobic soil metabolism half-life) and direct aquatic photolysis in (surface water, the disulfoton parent may degrade fairly rapidly (Howard, !991)). However, peak concentrations appear capable of being quite high, when high application rates used.

Limited ground water and surface water monitoring data available in the PGWDB (USEPA, 1992) and National Water-Quality Assessment (NAQWA) Program (USGS, 1997) tends to confirm fairly rapid degradation, as values measured values generally tend to be quite low. Although no assessment can be made for degradates due to lack of data, limited data suggests that the degradates are more persistent (>200 days) than disulfoton, suggesting their presence in water for an longer period of time than the parent. The degradates also appear to be more mobile than the parent compound.

Table . Disulfoton fate properties and values used in (GENEEC, PRZM3/EXAMs) modeling.		
Parameter	Value	Source
Molecular Weight	274.39	EFED One-liner 05/21/97
Water Solubility	25 mg/l @20	Berg, 1985; EFED One-liner 05/21/97
Henry’s Law Coefficient	2.60 atm-m3/mol	EFED One-liner 05/21/97
Partition Coefficient (Koc)	551.5 (mean of 4)	MRID 43042500
Vapor Pressure	1.8E-04 mmHg	EFED One-liner 05/21/97
Hydrolysis Half-lives @ pH 4 pH 7 pH 9	1174 days 323 “ 231 “	MRID 143405
Aerobic Soil Half-life	19.39 days (0.03575/d)	Upper 90% confidence bound on the mean of half-lives for the three aerobic soils tested in the laboratory. MRIDs 40042201, 41585101, 43800101
Water Photolysis	3.87 days (pH = 5) (0.179/d)	MRID 40471102
Aerobic Aquatic Half-life	no data	----

ii. Application Rates Used in Modeling

The application rates selected for use in the modeling scenarios were based upon information submitted by the registrant, analysis conducted by BEAD, and the disulfoton (Di-Syston) labels. Four factors went into selecting the application rate: 1) the range of ounces or pounds a.i.; 2) the area or length of row per acre (which is influenced by row spacing); 3) the number of applications; and 4) the application interval. The recommended and maximum rate (ounces or pounds a.i. per crop simulated) and the shortest application interval were selected. The shorter the distance between the crop rows the greater the application rate on an area basis. Two row spacing values were generally selected; one based on a near-the-maximum number of rows indicated by the label, and second based on the row spacing given in the label example (e.g., tobacco, page 8 of 14; 20 to 40 oz. per 1000 feet of row (for ”any row spacing”) or 13.3 to 26.7 lb. per acre or with a 48 inch row spacing). The label indicated that “any row spacing” could be as narrow as 6 inches. The narrowest row spacing used in this assessment was 12 inches. Thus a crop like tobacco had a range of application rates of 4.005 to 16.33 lb. a.i. per acre.

iii. Modeling Scenarios

Surface Water: The sites selected are currently used by EFED to represent a reasonable "at risk" soil for the region or regions being considered. The scenarios selected represent high-end exposure sites. The sites are selected so that they generate exposures larger than for most sites (about 90 percent) used for growing the selected crops. An "at risk" soil is one that has a high potential for run-off and soil erosion. Thus, these scenarios are intended to produce conservative estimates of potential disulfoton concentrations in surface water. The crop, MLRA, state, site, and soil conditions for the scenarios considered are given in **Tables and .**

Table . Crop, location, soil and hydrologic group for each modeling scenario.

Crop	MLRA[1]	State	Soil Series	Soil Texture	Hydrologic Group	Period (Years)
Barley	136	VA	Gaston	sandy clay loam	C	27
Cotton	134	MS	Loring	silt loam	C	36
Potatoes	144A	ME	Paxton	sandy loam	C	36
Tobacco	133A	GA	Emporia	loamy sand	C	36
Spr.Wheat	102A	SD	Peever	clay loam	C	40

[1]MLRA is major land resource area (USDA, 1981).

Table . Selected soil properties used modeling.

Soil Series (MLRA)	Depth (in)	Bulk Density (g/cm^3)	Organic Carbon (%)	Field Capacity (cm^3/cm^3)	Wilting Point (cm^3/cm^3)
Gaston (136)	16	1.6	1.740	0.246	0.126
	84	1.6	0.174	0.321	0.201
	50	1.6	0.116	0.222	0.122
Loring (134)	10	1.6	1.160	0.294	0.094
	10	1.6	1.160	0.294	0.094
	105	1.8	0.174	0.147	0.087
Paxton (144A)	20	1.6	2.90	0.166	0.66
	46	1.8	0.174	0.118	0.38

	34	1.8	0.116	0.085	0.035
Emporia (133A)	38	1.4	1.16	0.104	0.054
	62	1.6	0.174	0.225	0.125
	50	1.6	0.116	0.135	0.056
Peever (102A)	18	1.35	1.740	0.392	0.202
	82	1.60	0.116	0.257	0.177
	50	1.60	0.058	0.256	0.176

Ground Water: The SCI-GROW (Screening Concentration in Ground Water) screening model developed in EFED (Barrett, 1997) was used to estimate potential ground water concentrations for disulfoton parent under "generic" hydrologically vulnerable conditions. The SCI-GROW model is a model for estimating concentrations of pesticides in ground water under "worst case" conditions. SCI-GROW provides a screening concentration; an estimate of likely ground water concentrations if the pesticide is used at the maximum allowed label rate in areas with ground water exceptionally vulnerable to contamination. In most cases, a majority of the use area will have ground water that is less vulnerable to contamination than the areas used to derive the SCI-GROW estimate.

The SCI-GROW model is based on scaled ground water concentrations from ground water monitoring studies, environmental fate properties (aerobic soil half-lives and organic carbon partitioning coefficients-Koc's) and application rates.

iv. Modeling Procedure

Environmental fate parameters used in PRZM3 and EXAMS runs are summarized in **Table** . The standard pond (mspond) was used. The PRZM3 simulations were run for a period of 36 years on cotton, potatoes, and tobacco, beginning on January 1, 1948 and ending on December 31, 1983. Barley was run for 27 years (1956-1983) and spring wheat was run for 40 years (1944-1983). Scenario information is summarized in **Tables and .** The EXAMS loading (P2E-C1) files, a PRZM3 output, were pre-processed using the EXAMSBAT post-processor. EXAMS was run for the 27-40 years using Mode 3 (defines environmental and chemical pulse time steps). For each year simulated, the annual maximum peak, 96-hour, 21-day, 60-day, 90-day values, and the annual means were extracted from the EXAMS output file REPORT.XMS with the TABLE20 post-processor. The 10 year return EECs (or 10% yearly exceedance EECs) listed in **Table** were calculated by linear interpolation between the third and fourth largest values by the program TABLE20. Cumulative frequency plots for each scenario are provided in Appendix V.

v. Modeling Results

a. Surface water

In the Tier II assessment, the 90th percentile of the estimated multiple year mean concentrations of disulfoton in a farm pond over multiple years simulated ranged from 3.08 µg/L for a single maximum application (@1.00 lb ai/a) to spring wheat in South Dakota to 43.24 µg/L for potatoes in Maine with the two applications at the maximum application rate (@9.39 lb ai/ac). Maximum, or peak, estimated concentrations of 117.0 µg/L occurred for two 9.39 lb. ai/ac applications of disulfoton to potatoes. For the other scenarios or recommended application rates, the maximum concentrations ranged from 7.72 to 98.19 µg/L. Because of limited data, the modeling results; therefore, cannot be confirmed by the monitoring data.

The PRZM/EXAMs estimated disulfoton residue concentrations in surface water appear to be strongly related to application rate, number of applications, application interval, and method of application.

As noted previously the EECs estimated in Tier I by GENEEC were greater than those estimated by PRZM/EXAMS with exception of the multiple year, cotton scenarios (results were about the same). Single year PRZM/EXAMS estimates were lower than the disulfoton concentrations predicted by GENEEC. Thus, it appeared as if disulfoton is accumulating in multiple year scenarios (there was a general increase with time). This appears to be occurring because there is limited (available) information concerning the degradation of disulfoton in an aquatic environment (e.g., no aerobic aquatic half-life data). Since the disulfoton is stable to hydrolysis at environmental temperatures (e.g., 20 ^{o}C) and neutral pH (pH = 7), the only route of degradation considered in EXAMS is photolysis. Therefore, for years with high run-off , estimated concentrations will be “high” and decline slowly due to limited dissipation pathways.

Table . Tier II Upper Tenth Percentile EECs for Disulfoton Used on barley, cotton, potatoes, tobacco, and spring wheat for several application (recommended and maximum) rates and management scenarios estimated using PRZM3/EXAMs.

Crop	Disulfoton Application	Concentration (µg/L) (1-in-10 annual yearly maximum value)					
	Rate/Number/Interval/Incorp. Depth						
	lb.ai../ac/ #/ days/ inches	Peak	96-Hour Avg.	21-Day Avg.	60-Day Avg.	90-Day Avg.	Annual Avg.
Barley[1]	1.00/2/21/0	17.92	17.48	15.85	13.95	12.59	7.12
Barley	0.83/2/21/0 (aerial)	18.02	17.62	16.50	14.75	13.56	7.75
Cotton[1]	1.01/3/21/2.5	16.75	16.35	14.98	13.39	12.63	7.47
Cotton	3.27/3/21/2.5	54.24	52.97	48.54	43.35	40.91	24.20
Potatoes[1]	4.01/2/14/2.5	22.08	21.62	20.21	17.78	16.13	7.98

Potatoes	9.39/2/14/0	117.00	114.50	106.50	93.54	85.92	43.24
Potatoes[1]	4.00/2/14/0	49.76	48.69	45.44	39.84	36.59	18.42
Potatoes	9.39/2/14/2.5	51.78	50.69	47.39	41.69	37.83	18.71
Tobacco	8.17/1/0/2.5 (aerial)	98.19	95.71	87.30	75.11	68.75	40.33
Tobacco[1]	4.00/1/0/2.5	20.85	20.27	18.24	15.70	14.38	8.17
Tobacco	16.33/1/0/2.5	85.02	82.66	74.36	64.00	58.62	33.29
Spr.Wheat[1]	1.00/1/0/0	7.90	7.72	7.08	6.03	5.51	3.08
Spr.Wheat	0.64/1/0/0 (aerial)	10.20	9.96	9.44	8.32	7.71	4.77

[1] Rate recommended on label.

b. Ground water

The maximum disulfoton ground water concentration predicted by the SCI-GROW model (based on 2 maximum (e.g., potatoes) applications at 9.39 lb. a.i./ac) was 0.83 µg/L.

vi. Disulfoton Monitoring Data

The Pesticides in Ground Water Data Base (USEPA, 1992) summarizes the results of a number of ground-water monitoring studies conducted which included disulfoton (and disulfoton degradates D. sulfone and D. sulfoxide). Monitoring, with no detections (limits of detections ranged from 0.01 to 6.0 µg/L), have occurred in the follow states (number of wells): AL (10), CA (974), GA (76), HI (5), IN (161), ME (71), MS (120), MN (754), OK (1), OR (70), and TX (188). Disulfoton residues were detected in ground water in Virginia and Wisconsin. In Virginia, 6 of the 12 wells sampled had disulfoton detections ranging from 0.04 to 2.87 µg/L. In Wisconsin, 14 of 26 wells sampled had disulfoton residues ranging from 4.0 to 100.0 µg/L. The Wisconsin study could not be located to determine the source of the high value found. One hundred twenty wells were analyzed in MS for degradates D. sulfone and D. sulfoxide and 188 wells were analyzed in TX for D. sulfone. Limits of detection were 3.80 and 1.90 µg/L for the sulfone and sulfoxide degrade, respectively, in MS. There were no degradates reported in these samples. Disulfoton residues were found in 10 (0.37%) out of 2700 surface water samples collected by the USGS in the NAWQA (USGS, 1997) and are summarized in Table . Concentrations ranged from 0.02 to 0.041 µg/L with a minimum detection limit (MDL) of 0.017 µg/L/L. There were no detections reported in ground water in about 2200 ground-water samples.

Table . Summary of Detections in USGS NAQWA Study (USGS, 1997[1]).

Water Source	%> 0.01 µg/L	Maximum Concentration
Agricultural Streams	0.2	0.041
Urban Streams	0.0	0.007
Integrated Streams	0.0	0.002
Agricultural Wells	0.0	0.002
Urban Wells	0.0	None
Major Aquifers	0.0	None

[1] USGS, 1997 NAQWA, (URL http://water.wr.usgs.gov/pnsp/gwswl.html, August 1997)

It should be noted that all the detections of disulfoton residues in ground water in Wisconsin (range 4.0 to 100.0 µg/L) and some detections in Virginia (range 0.04 -2.87 µg/L) exceeded the concentrations predicted by SCI - GROW (0.83 µg/L). Although SCI-GROW is conservative based on a regression relationship between monitoring data (detected concentrations) and pesticide fate chemistry at vulnerable sites, SCI-GROW does not account for preferential flow, point-source contamination, pesticide spills, misuses, or pesticide storage sites. Many unknowns, data limitations, on-site variability were also present in the prospective ground-water monitoring studies which were not included when developing SCI-GROW.

Several limitations for the monitoring data should be noted. These limitations include: the use of different limit of detections between studies, lack of information concerning disulfoton use around sampling sites, and lack of data concerning the hydrogeology of the study sites.

vii. Limitations of this Modeling Analysis

There are several factors which limit the accuracy and precision of this modeling analysis including the selection of the high-end exposure scenarios, the quality of the data, the ability of the model to represent the real world, and the number of years that were modeled. There are additional limitations on the use of these numbers as an estimate of drinking water exposure. Degradation/metabolism products were also not considered due to lack of data. Another major limitation in the current EXAMS simulations is that the aquatic (microbial) degradation pathway was not considered due to lack of data. As noted above, this may result in an accumulation of disulfoton residues over time. Direct aquatic photolysis was however included.

Spray drift is determined by method of pesticide application, and is assumed to be 0% percent when applied as broadcast (granular) or in-furrow, 1% for ground spray, and 5% for aerial spray.

Tier II scenarios are also ones that are likely to produce high concentrations in aquatic environments. The scenarios were intended to represent sites that actually exist and are likely to be treated with a pesticide. These sites should be extreme enough to provide a conservative estimates of the EEC, but not so extreme that the model cannot properly simulate the fate and transport processes at the site. The EECs in this analysis are accurate only to the extent that the sites represent the hypothetical high exposure sites. The most limiting aspect of the site selection is the use of the "standard pond" which has no outlet. It also should be noted that the standard pond scenario used here would be expected to generate higher EECs than most water bodies; although, some water bodies would likely have higher concentrations (e.g., a shallow water bodies near agriculture fields that receive direct run-off from the treated field).

The quality of the analysis is also directly related to the quality of the chemical and fate parameters available for disulfoton. Acceptable data are available, but rather limited. Data were not available for degradates and the aquatic aerobic metabolism rate was not known, but estimated. Degradates with greater persistence and greater mobility would be expect to have a higher likelihood of leaching to ground water, with greater concentrations in surface water. The measured aerobic soil metabolism data is limited, but has sufficient sample size to establish an upper 90% confidence bound on the mean of half-lives for the three aerobic soils tested in the laboratory (and submitted to EFED) and reported in the EFED One-liner Database (MRIDs 40042201, 41585101, 43800101). The use of the 90%-upper bound value may be sufficient to capture the probable estimated environmental concentration when limited data are available.

The models themselves represent a limitation on the analysis quality. These models were not specifically developed to estimate environmental exposure in drinking water so they may have limitations in their ability to estimate drinking water concentrations. Aerial spray drift reaching the pond is assumed to be 5 percent of the application rate and for ground spray it is 1 percent of the application rate. No drift was assumed for broadcast or in-furrow applications. Another limitation is the lack of field data to validate the predicted pesticide run-off. Although, several of the algorithms (volume of run-off water, eroded sediment mass) are somewhat validated and understood, the estimates of pesticide transport by PRZM3 has not yet been fully validated Other limitations of the models are the inability to handle within site variation (spatial variability), crop growth, and the overly simple soil water balance. Another limitation is that 27 to 40 years of weather data was available for the analysis. Consequently there is a 1 in 27, 36, or 40 chance that the true 10% exceedance EECs are larger than the maximum EEC in the analysis. If the number of years of weather data were increased, it would increase the level of confidence that the estimated value for the 10% exceedance EEC was close to the true value.

EXAMS is primarily limited because it is a steady-state model and cannot accurately characterize the dynamic nature of water flow. A model with dynamic hydrology would more accurately reflect concentration changes due pond overflow and evaporation. Thus, the estimates derived from the current model simulates a pond having no-outlets, flowing water, or turnover. Another major limitation in the current EXAMs simulations is that the aquatic (microbial) degradation pathway was not considered due to lack of data. Direct aquatic photolysis was however included.

Another important limitation of the Tier II EECs for drinking water exposure estimates is the use of a single 10 hectare drainage basin with a 1 hectare pond. It is unlikely that this small system accurately represents the dynamics in a watershed large enough to support a drinking water utility. It is unlikely that an entire basin, with an adequate size to support a drinking water utility would be planted completely in a single crop or be represented by scenario being modeled. The pesticides would more likely be applied over several days to weeks rather than on a single day. This would reduce the magnitude of the conservative concentration peaks, but also make them broader, reducing the acute exposure, but perhaps increasing the chronic exposure.

Monitoring data is limited by the lack of correlation between sampling date and the use patterns of the pesticide within the study's drainage basin. Additionally, the sample locations were not associated with actual drinking water intakes for surface water nor were the monitored wells associated with known ground water drinking water sources. Also, due to many different analytical detection limits, no specified detection limits, or extremely high detection limits, a detailed interpretation of the monitoring data is not always possible.

A model with dynamic hydrology would more accurately reflect concentration changes due pond overflow and evaporation. Thus, the estimates derived from the current model simulates a pond having no-outlets, flowing water, or turnover. Another major limitation in the current EXAMs simulations is that the aquatic (microbial) degradation pathway was not considered due to lack of data. Direct aquatic photolysis was however included.

3. Ecological Effects Hazard Assessment

A. Toxicity to Terrestrial Animals

I. Birds, Acute and Subacute

An acute oral toxicity study using the technical grade of the active ingredient is required to establish the toxicity of a pesticide to birds. The preferred test species is either mallard duck or bobwhite quail. Results of this test are tabulated below. Acute oral testing was also performed with the 15G formulation of disulfoton. Additionally, acute oral testing was required for the two major degradation products of disulfoton, disulfoton sulfone and disulfoton sulfoxide, due to their relative persistence. These test results are tabulated below.

Table . Avian Acute Oral Toxicity

Species	% ai	LD50 (mg/kg)	Toxicity Category	MRID No. Author/Year	Study Classification
Mallard *(Anas platyrhynchos)*	97	6.54	very highly toxic	00160000 1984/Hudson	supplemental

Table . Avian Acute Oral Toxicity

Species	% ai	LD50 (mg/kg)	Toxicity Category	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	technical	12.0	highly toxic	EDODIS00 Hill	core
Northern bobwhite quail *(Colinus virginianus*	technical	28	highly toxic	0095655 1977	core
Northern bobwhite quail *(Colinus virginianus)*	technical	31	highly toxic	0095655 1977	core
Northern bobwhite quail *(Colinus virginianus)*	98.7	39	highly toxic	42585803 /1992	core
Ring-necked pheasant *(Phasianus colchicus)*	technical	11.9	highly toxic	00160000 1987/Hudson	core
Red-winged blackbird (*Agelaius phoeniceus*)	technical	3.2	very highly toxic	1987	supplemental
Northern bobwhite quail *(Colinus virginianus)*	15G	220	moderately toxic	25525 1969	core
Northern bobwhite quail *(Colinus virginianus)*	15G	97	moderately toxic	25525 1969	core
Northern bobwhite quail *(Colinus virginianus)*	15G	14.5	highly toxic	0095655 1984	supplemental
Northern bobwhite quail *(Colinus virginianus)*	15G	29	highly toxic	EDODIS00 1984	supplemental
Northern bobwhite quail *(Colinus virginianus)*	sulfone metabolite 87.4	18	highly toxic	42585103 1992	core
Northern bobwhite quail *(Colinus virginianus)*	sulfoxide metabolite 85.3	9.2	very highly toxic	42585102 1992	core

These results indicate that disulfoton is highly toxic to very highly toxic to avian species on an acute oral basis.   The guideline requirement (71-1) is fulfilled (MRID # 42585803). Additionally, the two major metabolites of disulfoton, disulfoton sulfone and disulfoton sulfoxide, are highly toxic and very highly toxic, respectively. Guideline 71-1 is fulfilled for the two major degradates of disulfoton (42585103 and 42585102).

Two subacute dietary studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to birds. The preferred test species are mallard duck (a waterfowl) and bobwhite quail (an upland gamebird). Subacute dietary testing on the two major metabolites of disulfoton, disulfoton sulfone and disulfoton sulfoxide, were also required, due to the relative persistence of these degradates. Results of all avian subacute dietary tests are tabulated below.

Table . Avian Subacute Dietary Toxicity

Species	% ai	LC50 (ppm)	Toxicity Category	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	technical	544	moderately toxic	0094233 Lamb/1973	core
Mallard duck *(Anas platyrhynchos)*	technical	510	moderately toxic	0034769 Hill/1975	core
Mallard duck *(Anas platyrhynchos)*	sulfone metabolite 87.4	622	moderately toxic	42585101 1992	core
Northern bobwhite quail *(Colinus virginianus)*	sulfone metabolite 87.4	558	moderately toxic	42585106 1992	core
Mallard duck *(Anas platyrhynchos)*	sulfoxide metabolite 85.3	823	moderately toxic	42585104 1992	core
Northern bobwhite quail *(Colinus virginianus)*	sulfoxide metabolite 85.3	456	highly toxic	42585105 1992	core

These results indicate that disulfoton is highly toxic to avian species on a subacute dietary basis. The guideline requirement (71-2) is fulfilled (ACC # 0094233 and 0034769). Additionally, the major metabolites of disulfoton, disulfoton sulfone and disulfoton sulfoxide, are highly toxic to very highly toxic to avian species on a dietary basis. Guideline 71-2 is fulfilled for both metabolites (MRID #42585101, 42585106, 42585104, and 42585105).

ii. Birds, Chronic

Avian reproduction studies using the technical grade of the active ingredient are required for disulfoton because the following conditions are met: (1) birds may be subject to repeated or continuous exposure to the pesticide, especially preceding or during the breeding season, (2) the pesticide is stable in the environment to the extent that potentially toxic amounts may persist in animal feed, (3) the pesticide is stored or accumulated in plant or animal tissues, and/or, (4) information derived from mammalian reproduction studies indicates reproduction in terrestrial vertebrates may be adversely affected by the anticipated use of the product. Disulfoton meets all of these conditions. The preferred test species are mallard duck and bobwhite quail. Results of these tests are tabulated below.

Table . Avian Reproductive Toxicity

Species	% ai	NOEC/LOEC (ppm)	Endpoints Affected	MRID No. Author/Year	Study Classification
Northern bobwhite quail *(Colinus virginianus)*	98.7	37/74	hatchling body weight	43032501 /1993	core
Mallard duck *(Anas platyrhynchos)*	98.3	37/80	adult and hatchling body weight	43032502 /1993	core

There was a statistically significant reduction in hatchling body weight at 74 ppm in the bobwhite quail study; however, there were no significant differences in hatchling body weights by day 14 post-hatch. No other effects were observed in this study.

Adult and hatchling body weights were significantly reduced at 80 and 164 ppm in the mallard study, and body weight gain in adults was significantly reduced throughout the study at these two treatment levels as well. Other effects observed at the 164 ppm level were: significantly fewer eggs laid per hen, reduced eggshell strength and thickness, reduced number of hatchlings as a percent of viable embryos, reduced number of 14-day survivors as a percent of normal hatchlings, reduced viable embryos as a percent of eggs set, and reduced 14-day survivors as a percentage of eggs set. The guideline requirement for avian reproduction testing (71-4) is fulfilled (MRID # 43032501, and 43032502).

iii. Mammals, Acute and Chronic

Wild mammal testing is required on a case-by-case basis, depending on the results of lower tier laboratory mammalian studies, intended use pattern and pertinent environmental fate characteristics. In most cases, rat or mouse toxicity values obtained from the Agency's Health Effects Division (HED) substitute for wild mammal testing. These toxicity values are reported in the Table below.

Table . Mammalian Acute Toxicity				
Species	% ai	Test Type	Toxicity Values/category	MRID No.
Mule deer (*Odocoileus hemionus*)	97	acute oral	2.5 mg/kg very highly toxic	00160000
Domestic goat (*Capra hircus*)	97	acute oral	< 15 mg/kg very highly toxic	00160000
Laboratory rat *(Rattus norvegicus)*	94.4	acute oral	1.9 mg/kg females I 6.2 mg/kg males I	072293
Laboratory mouse *(Mus musculus)*	94.4	acute oral	8.2 mg/kg (female) I 7.0 mg/kg (male) I	072293
Laboratory rat *(Rattus norvegicus)*	sulfone metabolite	acute oral	11.24 mg/kg (female)I	0071873

Test results indicate that disulfoton is very highly toxic (Category I) to small mammals on an acute oral basis. Testing on the sulfone metabolite also indicates very high acute oral toxicity.

Table . Mammalian Chronic Toxicity				
Species	% ai	Test Type	Toxicity Values/category	MRID No.
Laboratory rat *(Rattus norvegicus)*	97.8	2-generation reproduction	maternal NOEC=2.4 ppm/LOEC=7.2 ppm repro NOEC=0.8 ppm/LOEC=2.4 ppm	261990

The two-generation rat reproduction study provided a reproductive NOEC level of 0.8 ppm. Parameters affected in the study included decreased litter size, lowered pup survival, and decreased pup weight.

iv. Insects

A honey bee acute contact study using the technical grade of the active ingredient is required for disulfoton because its use may result in honey bee exposure. Results of this test are tabulated below.

Table . Nontarget Insect Acute Contact Toxicity					
Species	% ai	LD50 (μg/bee)	Toxicity Category	MRID No. Author/Year	Study Classification
Honey bee *(Apis mellifera*)	technical	4.1	very highly toxic	05004151 1968	core
Honey bee *(Apis mellifera)*	sulfone metabolite 91.6	0.96	very highly toxic	42582902 1992	core
Honey bee *(Apis mellifera)*	sulfoxide metabolite 85.3	1.11	very highly toxic	42582901 1992	core

The results indicate that disulfoton, disulfoton sulfone, and disulfoton sulfoxide are very highly toxic to bees on an acute contact basis. The guideline requirement (141-1) is fulfilled for parent disulfoton (MRID #05004151), as well as for the two major metabolites (MRID #42582902, 42582901).

A honey bee toxicity of residues on foliage study using the typical end-use product is required for disulfoton due to the very high toxicity of the parent in the acute contact study. The results of this study are tabulated below.

Table . Nontarget Insect Toxicity of Residues on Foliage					
Species	Formulatio n	LD50 (Lb /A)	Toxicity Category	MRID or ACC # Author/year	Guideline Classification
Honey bee *(Apis mellifera*	8 EC	> 1.0		0163423	core

The results indicate that disulfoton residues on foliage are not toxic to honey bees at application rates up to 1.0 lb /A. Guideline 141-2 is fulfilled for disulfoton (ACC #0163423).

v. Terrestrial Field Testing

Terrestrial field testing was conducted for disulfoton because of the high toxicity of the chemical in relation to expected environmental concentrations. Three field monitoring studies were originally required in the 1985 Registration Standard, but only one screening level field study and one residue monitoring study were submitted. The Level I (screening) field study was conducted on potatoes in Benton county, Washington, using the 15G formulation (MRID #410560-01). The study did show mortality to wildlife from the use of the 15G formulation on potatoes; since it was a screening study, there were no further conclusions. The residue monitoring study (MRID #412018-01) was performed using Di-Syston 8 (foliar) on potatoes in

Michigan. The results of this study indicated that there was hazard to terrestrial wildlife from the foliar application of disulfoton, and also suggested that a full Level 1 field study was needed with the foliar application. An additional residue monitoring study (MRID #411189-01), in which disulfoton was applied to the soil, indicated that the residues from the soil application are not expected to pose a hazard to terrestrial wildlife. These studies fulfill Guideline 71-5 only because they showed adverse effects. If no mortality had been observed, the studies would not have been classified as core as the study design and carcass searching techniques were insufficient to negate the presumption of risk. The fact that bird and mammal carcasses were found even with such an insensitive study design emphasizes the high acute risk this chemical poses to terrestrial organisms.

B. Toxicity to Freshwater Aquatic Animals

I. Freshwater Fish, Acute

Two freshwater fish toxicity studies using the technical grade of the active ingredient are required to establish the toxicity of a pesticide to fish. The preferred test species are rainbow trout (a coldwater fish) and bluegill sunfish (a warmwater fish). Results of these tests are tabulated below.

Table . Freshwater Fish Acute Toxicity

Species	% ai	LC50 (ppb ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)*	98	1,850	moderately toxic	40098001 F.L. Mayer/1986	core
	tech	3,000	moderately toxic	0068268 Lamb/1972	core
	15G	13,900	slightly toxic	0068268 Lamb/1972	core
	65EC	3,500	moderately toxic	0068268 Lamb/1972	core
	sulfone metabolite	>9,200	moderately toxic	42585111 Gagliano/1992	core
	sulfoxide metabolite	60,300	slightly toxic	42585110 Gagliano/1992	core

Table . Freshwater Fish Acute Toxicity					
Species	% ai	LC50 (ppb ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Bluegill sunfish *(Lepomis macrochirus*	98.0	300	highly toxic	40098001 F.L. Mayer/1986	core
	Tech	39	very highly toxic	0068268 Lamb/1972	core
	15G	250	highly toxic	0068268 Lamb/1972	core
	65EC	59	very highly toxic	0068268 Lamb/1972	core
	20E	8.2	very highly toxic	229299 1962	supplemental
	sulfone metabolite	112	highly toxic	42585108 Gagliano/1992	core
	sulfoxide metabolite	188	highly toxic	42585107 Gagliano/1992	core
Channel catfish (*Ictalurus punctatus*)	98.0	4,700	moderately toxic	40098001 Mayer/1986	core
Goldfish (*Carassius auratus*)	90	7,200	moderately toxic	229299 1962	supplemental
Largemouth bass (*Micropterus salmoides*)	98.0	60	very highly toxic	40098001 Mayer/1986	core
Fathead minnow (*Pimphales promelas*)	98.0	4,300	moderately toxic	40098001 Mayer/1986	core
Guppy (*Poecilia reticulata*)	90	280	highly toxic	229299 1962	supplemental

These results indicate that parent disulfoton is very highly toxic to slightly toxic to freshwater fish on an acute basis. The two major metabolites, disulfoton sulfone and disulfoton sulfoxide, are highly toxic to slightly toxic to freshwater fish on an acute basis. The rainbow trout, a coldwater species, appears to be somewhat less sensitive than the warmwater species to disulfoton and its metabolites. The guideline requirement (72-1) is fulfilled for parent disulfoton, disulfoton sulfone, and disulfoton sulfoxide.

ii. Freshwater Fish, Chronic

A freshwater fish early life-stage test using the technical grade of the active ingredient is required for a pesticide when it may be applied directly to water or if the end-use product is expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, (2) any aquatic acute LC50 or EC50 is less than 1 mg/l, (3) the EEC in water is equal to or greater than 0.01 of any acute LC50 or EC50 value, or, (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any acute LC50 or EC50 value and any one of the following conditions exist: studies of other organisms indicate the reproductive physiology of fish may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water (e.g., half-life greater than 4 days). The preferred test species is rainbow trout, but other species may be used.. Freshwater fish early life-stage testing was required for disulfoton due to the likelihood of runoff from the application sites, the likelihood of repeated or continuous exposure from multiple applications, and the high acute toxicity to several species of freshwater fish. Results of this test are tabulated below.

Table . Freshwater Fish Early Life-Stage Toxicity

Species	% ai	NOEC/LOEC (ppb ai)	MATC (ppb)	Endpoints Affected	MRID No. Author/Year	Study Classification
Rainbow trout *(Oncorhynchus mykiss)*	98	220/420	300	growth	41935801 1991	core

The guideline requirement (72-4a) is fulfilled (MRID 41935801).

A freshwater fish life-cycle test using the technical grade of the active ingredient is not required for disulfoton. A marine/estuarine fish life-cycle test was conducted with disulfoton, since the marine/estuarine species is more sensitive than the freshwater species. This is discussed in section c ii , below.

iii. Freshwater Invertebrates, Acute

A freshwater aquatic invertebrate toxicity test using the technical grade of the active ingredient is required to establish the toxicity of a pesticide to invertebrates. The preferred test species is *Daphnia magna*. Results of this test are tabulated below.

Table . Freshwater Invertebrate Toxicity					
Species	% ai	LC50/ EC50 (ppb ai)	Toxicity Category	MRID No. Author/Year	Study Classification
Waterflea *(Daphnia magna)*	98.6	13.0	very highly toxic	00143401 Heimbach/1985	core
	Sulfone metabolite	35.2	very highly toxic	42585112 Gaglaino/1992	core
	sulfoxide metabolite	64	very highly toxic	42585109 Gagliano/1992	core
Scud (*Gammarus fasciatus*)	98	52	very highly toxic	40098001 Mayer/1986	supplemental
	technical	27	very highly toxic	05017538 1972	supplemental
Glass shrimp (*Palaemonetes kadiakensis*)	98	3.9	very highly toxic	40094602 1980	supplemental
Stonefly (*Acroneuria pacifica*)	89	<8.2	very highly toxic	229299 1962	supplemental
Stonefly (*Pteronarcys californica*)	98	5.0	very highly toxic	40098001 Mayer/1986	core

The results indicate that disulfoton and its metabolites, disulfoton sulfone and disulfoton sulfoxide, are very highly toxic to aquatic invertebrates on an acute basis. The guideline requirement (72-2) is fulfilled.

iv. Freshwater Invertebrate, Chronic

A freshwater aquatic invertebrate life-cycle test using the technical grade of the active ingredient is required for a pesticide if the end-use product may be applied directly to water or expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, (2) any aquatic acute LC50 or EC50 is less than 1 mg/l, or, (3) the EEC in water is equal to or greater than 0.01 of any acute EC50 or LC50 value, or, (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any aquatic acute EC50 or LC50 value and any of the following conditions exist: studies of other organisms indicate the reproductive physiology of invertebrates may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water (e.g., half-life greater than 4 days). The preferred test species is *Daphnia magna*. Freshwater aquatic invertebrate life-cycle testing was required for disulfoton. Results of this test are tabulated below.

Table . Freshwater Aquatic Invertebrate Life-Cycle Toxicity						
Species	% ai	NOEC/LOEC (ppb)	MATC (ppm)	Endpoints Affected	MRID No. Author/Year	Study Classification
Waterflea *(Daphnia magna)*	98	0.037/0.070	0.051	survival, length, and # young/adult	41935802 Blakemore/1991	core

The guideline requirement (72-4) is fulfilled (MRID #41935802).

v. Freshwater Field Studies

A microcosm study was conducted to evaluate the effects of runoff of disulfoton on a simulated aquatic field system (MRID #435685-01/Cook and Kennedy, 1994). The study demonstrated that 3 ppb is the maximum acceptable toxicant concentration (MATC) for this chemical in aquatic systems. At treatment levels of 3 ppb and higher, adverse effects were seen on zooplankton numbers, zooplankton community similarity, adult macroinvertebrate population numbers, and adult macroinvertebrate community composition; however, some recovery trend was observed on these parameters.

C. Toxicity to Estuarine and Marine Animals

I. Estuarine and Marine Fish, Acute

Acute toxicity testing with estuarine/marine fish using the technical grade of the active ingredient is required for a chemical when the end-use product is intended for direct application to the marine/estuarine environment or the active ingredient is expected to reach this environment because of its use in coastal counties. The preferred test species is sheepshead minnow. Marine/estuarine acute testing was conducted with disulfoton. Results of these tests are tabulated below.

Table . Acute Toxicity of Disulfoton to Estuarine/Marine Fish					
Species	% ai	LC50 (ppb)	Toxicity Category	MRID No. Author/Year	Study Classification
Sheepshead minnow *(Cyprinodon variegatus)*	95.5	520	highly toxic	4022840 Mayer/1986	supplemental
Sheepshead minnow (*Cyprinodon variegatus*)	97.8	1000	highly toxic	40071602 Surprenant/1986	core

Table . Acute Toxicity of Disulfoton to Estuarine/Marine Fish					
Species	% ai	LC50 (ppb)	Toxicity Category	MRID No. Author/Year	Study Classification
Sheepshead minnow (*Cyprinodon variegatus*)	Sulfone metabolite 100%	1060	moderately toxic	44369901 Lam/1997	core
Sheepshead minnow (*Cyprinodon variegatus*)	Sulfoxide metabolite 98.2%	11300	slightly toxic	44369902 Lam/1997	core

The results indicate that disulfoton is highly toxic to estuarine/marine fish on an acute basis. The guideline requirement (72-3a) is fulfilled for parent disulfoton (MRID #40071602) and the sulfone and sulfoxide metabolites (MRID #44369901 and 44369902, respectively)..

ii. Estuarine and Marine Fish, Chronic

Estuarine/marine fish early life-stage and life-cycle tests using the technical grade of the active ingredient were required for disulfoton due to the high acute toxicity to estuarine/marine fish. The results of these studies are tabulated below.

Table : Chronic Toxicity of Disulfoton to Marine/Estuarine Fish							
Species	% a.i.	Test Type	NOEC/LOEC (ppb)	MATC (ppb)	Parameters Affected	MRID # Author/year	Classification
Sheepshead minnow (*Cyprinodon variegatus*)	97.4	early life-stage	16.2/32.9	23.1	survival, length, wet weight	42629001 Lintott/1993	core
Sheepshead minnow (*Cyprinodon variegatus*)	98	life-cycle	0.96[1] /2.9	1.7	fecundity, morphological abnormalities, growth, hatching success	43960501 Dionne/1996	supplemental

[1]An actual NOEC was not achieved in this study. The value reported here is an EC05, extrapolated using linear regression.

The results indicate that disulfoton impacts the reproductive ability, as well as the growth and larval survival, of sheepshead minnows at levels as low as 2.9 ppb. The guideline requirements (72-4 and 72-5) are fulfilled (MRID # 42629001 and 43960501, respectively).

iii. Estuarine and Marine Invertebrates, Acute

Acute toxicity testing with estuarine/marine invertebrates using the technical grade of the active ingredient is required for a pesticide when the end-use product is intended for direct application to the marine/estuarine environment or the active ingredient is expected to reach this environment because of its use in coastal counties. The preferred test species are mysid shrimp and eastern oyster. Estuarine/marine invertebrate testing was required for disulfoton. Results of these tests are tabulated below.

Table : Acute Toxicity of Disulfoton to Estuarine/Marine Invertebrates

Species	% ai.	LC50/EC50 (ppb)	Toxicity Category	MRID No. Author/Year	Study Classification
Eastern oyster *(Crassostrea virginica)*	97.8	720	highly toxic	40071603 Surprenant/1986	core
Eastern oyster *(Crassostrea virginica)*	tech	900	highly toxic	120480 /1965	supplemental
Eastern oyster *(Crassostrea virginica)*	95.5	720	highly toxic	40228401 Mayer/1986	core
Mysid (*Mysidopsis bahia*)	97.8	100	very highly toxic	40071601 Surprenant/1986	core
Brown shrimp (*Penaeus aztecus*)	95.5	15	very highly toxic	40228401 Mayer/1986	supplemental

The results indicate that disulfoton is very highly to highly toxic to estuarine/marine invertebrates on an acute basis. The guideline requirements (72-3b and 72-3c) are fulfilled (MRID #40071603 and 40071601, respectively).

iv. Estuarine and Marine Invertebrate, Chronic

An estuarine/marine invertebrate life-cycle toxicity test is required for a pesticide if the end-use product may be applied directly to water or expected to be transported to water from the intended use site, and the following conditions are met: (1) the pesticide is intended for use such that its presence in water is likely to be continuous or recurrent regardless of toxicity, (2) any aquatic acute LC50 or EC50 is less than 1 mg/l, or, (3) the EEC in water is equal to or greater than 0.01 of any acute EC50 or LC50 value, or, (4) the actual or estimated environmental concentration in water resulting from use is less than 0.01 of any aquatic acute EC50 or LC50 value and any of the following conditions exist: studies of other organisms indicate the reproductive physiology of invertebrates may be affected, physicochemical properties indicate cumulative effects, or the pesticide is persistent in water (e.g., half-life greater than 4 days). Estuarine/marine invertebrate testing was required for disulfoton due to its high acute toxicity to estuarine/marine organisms, and the greater acute sensitivity of marine/estuarine organisms compared to freshwater organisms. The results of this test are tabulated below.

Table : Life-Cycle Toxicity of Disulfoton to Estuarine/Marine Invertebrates

Species	% ai	NOEC/LOEC (ppb)	MATC (ppb)	Parameters Affected	MRID # Author/Year	Classification
Mysid (*Mysidopsis bahia*)	98.5	2.35[1] /8.26	5.30	growth	43610901 Davis/1995	core

[1]A NOEC was not achieved in the study, so an extrapolated EC_{05} for growth was calculated using linear regression. The MATC reported is the mean between the EC_{05} and LOEC values.

The growth of mysids was adversely affected at levels of 8.26 ppb and higher. Production and survival of young was adversely affected at levels of 120 ppb and higher.

v. Estuarine and Marine Field Studies

No estuarine or marine field study data is available for disulfoton.

D.   Toxicity to Plants

I. Terrestrial

Currently, terrestrial plant testing is not required for pesticides other than herbicides except on a case-by-case basis (e.g., labeling bears phytotoxicity warnings, incidents of plant damage have been reported, or literature indicating phytotoxicity is available). The insecticide disulfoton does have phytotoxicity warnings on product labels; therefore, Tier I terrestrial plant testing (Guideline 122-1) is required for disulfoton. No such data have been submitted to date.

ii. Aquatic Plants

Aquatic plant testing is not required for pesticides other than herbicides except on a case-by-case basis (e.g., labeling bears phytotoxicity warnings, incidents have been reported involving plants, or literature is available that indicates phytotoxicity). The insecticide disulfoton does have phytotoxicity warnings on product labels; therefore, Tier I aquatic plant testing (Guideline 122-2) is required for disulfoton. No such data have been submitted to date.

4. Ecological Risk Assessment

Risk assessment integrates the results of the exposure and ecotoxicity data to evaluate the likelihood of adverse ecological effects. One method of integrating the results of exposure and ecotoxicity data is called the quotient method. For this method, risk quotients (RQs) are calculated by dividing exposure estimates by ecotoxicity values, both acute and chronic.

RQ = EXPOSURE/TOXICITY

RQs are then compared to OPP's levels of concern (LOCs). These LOCs are criteria used by OPP to indicate potential risk to nontarget organisms and the need to consider regulatory action. The criteria indicate that a pesticide used as directed has the potential to cause adverse effects on nontarget organisms. LOCs currently address the following risk presumption categories: (1) **acute high** - potential for acute risk is high regulatory action may be warranted in addition to restricted use classification (2) **acute restricted use** - the potential for acute risk is high, but this may be mitigated through restricted use classification (3) **acute endangered species** - the potential for acute risk to endangered species is high regulatory action may be warranted, and (4) **chronic risk** - the potential for chronic risk is high regulatory action may be warranted. Currently, EFED does not perform assessments for chronic risk to plants, acute or chronic risks to nontarget insects, or chronic risk from granular/bait formulations to mammalian or avian species.

The ecotoxicity test values (i.e., measurement endpoints) used in the acute and chronic risk quotients are derived from the results of required studies. Examples of ecotoxicity values derived from the results of short-term laboratory studies that assess acute effects are: (1) LC50 (fish and birds) (2) LD50 (birds and mammals (3) EC50 (aquatic plants and aquatic invertebrates) and (4) EC25 (terrestrial plants). Examples of toxicity test effect levels derived from the results of long-term laboratory studies that assess chronic effects are: (1) LOEC (birds, fish, and aquatic invertebrates) (2) NOEC (birds, fish and aquatic invertebrates) and (3) MATC (fish and aquatic invertebrates). For birds and mammals, the NOEC value is used as the ecotoxicity test value in assessing chronic effects. Other values may be used when justified. Generally, the MATC (defined as the geometric mean of the NOEC and LOEC) is used as the ecotoxicity test value in assessing chronic effects to fish and aquatic invertebrates. However, the NOEC is used if the measurement end point is production of offspring or survival.

Risk presumptions, along with the corresponding RQs and LOCs are tabulated below.

Risk Presumptions for Terrestrial Animals

Risk Presumption	RQ	LOC
Birds and Wild Mammals		
Acute High Risk	EEC[1]/LC50 or LD50/sqft[2] or LD50/day[3]	0.5
Acute Restricted Use	EEC/LC50 or LD50/sqft or LD50/day (or LD50 < 50 mg/kg)	0.2
Acute Endangered Species	EEC/LC50 or LD50/sqft or LD50/day	0.1
Chronic Risk	EEC/NOEC	1

[1] abbreviation for Estimated Environmental Concentration (ppm) on avian/mammalian food items

[2] $\dfrac{\text{mg/ft}^2}{\text{LD50 * wt. of bird}}$ [3] $\dfrac{\text{mg of toxicant consumed/day}}{\text{LD50 * wt. of bird}}$

Risk Presumptions for Aquatic Animals

Risk Presumption	RQ	LOC
Acute High Risk	EEC[1]/LC50 or EC50	0.5
Acute Restricted Use	EEC/LC50 or EC50	0.1
Acute Endangered Species	EEC/LC50 or EC50	0.05
Chronic Risk	EEC/MATC or NOEC	1

[1] EEC = (ppm or ppb) in water

Risk Presumptions for Plants

Risk Presumption	RQ	LOC
Terrestrial and Semi-Aquatic Plants		
Acute High Risk	EEC[1]/EC25	1
Acute Endangered Species	EEC/EC05 or NOEC	1
Aquatic Plants		
Acute High Risk	EEC[2]/EC50	1
Acute Endangered Species	EEC/EC05 or NOEC	1

[1] EEC = lbs ai/A
[2] EEC = (ppb/ppm) in water

A. Risk to Nontarget Terrestrial Animals

I. Birds

The acute risk quotients for broadcast applications of nongranular products are tabulated below.

Table . Avian Acute Risk Quotients for Single Application of Nongranular Products Based on a Mallard LC50 of 510 ppm .

Site/App. Method	App. Rate (lbs ai/A)	Food Items	Maximum EEC (ppm)	LC50 (ppm)	Acute RQ (EEC/ LC50)
Tobacco/aerial	4	Short grass	960	510	1.88 a
		Tall grass	440	510	0.86 a
		Broadleaf plants/Insects	540	510	1.06 a
		Seeds	60	510	0.12 c
Beans/ground	2	Short grass	480	510	0.94 a
		Tall grass	220	510	0.43 b
		Broadleaf plants/Insects	270	510	0.53 a
		Seeds	30	510	0.06
Broccoli and Wheat/soil	1	Short grass	240	510	0.47 b
		Tall grass	110	510	0.22 b
		Broadleaf plants/Insects	135	510	0.26 b
		Seeds	15	510	0.03

a exceeds acute high, acute restricted and acute endangered species LOCs.
b exceeds acute restricted and acute endangered species LOCs.
c exceeds acute endangered species LOC

An analysis of the results indicates that for a single application of nongranular products, avian acute high, restricted use, and endangered species levels of concern are exceeded at registered maximum application rates equal to or above 2 lb ai/A. Applications of 1 lb ai/A exceed avian acute restricted use and endangered species levels of concern.

The chronic risk quotients for a single application of nongranular disulfoton are tabulated below.

Table . Avian Chronic Risk Quotients for Single Applications of Nongranular Disulfoton Based on a Bobwhite Quail NOEC of 37 ppm .								
Site/App. Method	App. Rate (lbs ai/A)	Food Items	Maximum EEC (ppm)	60-Day Average EEC (ppm)	NOEC (ppm)	Maximum Chronic RQ (Maximum EEC/ NOEC)	Average Chronic RQ (Average EEC/ NOEC)	Number days LOC exceeded
Tobacco aerial	4	Short grass	960	338	37	25.90 a	9.14 a	60
		Tall grass	440	155	37	11.89 a	4.19 a	55
		Broadleaf plants/Insects	540	190	37	14.59 a	5.14 a	60
		Seeds	60	21	37	1.60 a	0.57	11
Beans ground	2	Short grass	480	169	37	12.97 a	4.57 a	57
		Tall grass	220	77	37	5.95 a	2.08 a	39
		Broadleaf plants/Insects	270	95	37	7.30 a	2.57 a	44
		Seeds	30	11	37	0.81	0.30	0
Broccoli/ Wheat soil	1	Short grass	240	84	37	6.50 a	2.27 a	42
		Tall grass	110	39	37	3.00 a	1.05 a	23
		Broadleaf plants/Insects	135	48	37	3.64 a	1.30 a	28
		Seeds	15	5	37	0.40a	0.14	0

a= chronic LOC has been exceeded

An analysis of the results indicate that for a single application of nongranular disulfoton, the avian chronic level of concern is exceeded at application rates equal to or above

1.0 lb ai/A for all food types except seeds. The avian chronic LOC for seeds is exceeded for single applications of 4.0 lb ai/A and greater.

The acute risk quotients for multiple applications of nongranular products of disulfoton are tabulated below. Maximum EECs result from the pesticide being applied repeatedly, but degrading over the course of time from the first application to the last application (FATE program).

Table . Avian Acute Risk Quotients for Multiple Applications of Non-Granular Disulfoton Based on a Mallard LC50 of 510 ppm.

Site/App. Method	App. Rate lbs ai/A (No. of Apps.)/Appl interval	Food Items	Maximum EEC[1] (ppm)	LC50 (ppm)	Acute RQ (EEC/ LC50)
Potatoes/ground	4 (2)/14	Short grass	1475	510	2.89 a
		Tall grass	677	510	1.33 a
		Broadleaf plants/Insects	830	510	1.63 a
		Seeds	92	510	0.18 c
Pecans/aerial	1 (3)/14	Short grass	438	510	0.70 a
		Tall grass	201	510	0.39 b
		Broadleaf plants/Insects	246	510	0.48 b
		Seeds	27	510	0.05
Cotton/foliar	2 (2)/21	Short grass	669	510	1.31 a
		Tall grass	307	510	0.60 a
		Broadleaf plants/Insects	376	510	0.74 a
		Seeds	42	510	0.08
Sorghum/ground	1 (2)/14 days	Short grass	369	510	0.72 a

Table . Avian Acute Risk Quotients for Multiple Applications of Non-Granular Disulfoton Based on a Mallard LC50 of 510 ppm.					
Site/App. Method	App. Rate lbs ai/A (No. of Apps.)/Appl interval	Food Items	Maximum EEC[1] (ppm)	LC50 (ppm)	Acute RQ (EEC/ LC50)
		Tall grass	169	510	0.33 b
		Broadleaf plants/Insects	208	510	0.41 b
		Seeds	23	510	0.04
Sorghum/foliar	0.5 (3)/14	Short grass	219	510	0.43 b
		Tall grass	100	510	0.20 b
		Broadleaf plants/Insects	123	510	0.24 b
		Seeds	14	510	0.03

1 Assumes degradation using FATE program.
a Exceeds acute high risk, restricted use and endangered species LOCs
b Exceeds acute restricted use and endangered species LOCs
c Exceeds acute endangered species LOC

The results indicate that for multiple applications of nongranular products, maximum residues on short grass will exceed the high acute risk, restricted use, and endangered species LOCs for application rates at or above 1 lb ai/A. Maximum residues on tall grass and broadleaf plants, as well as on insects, will exceed the high acute risk, restricted use, and endangered species LOCs at application rates at or above 2 lb ai/A.

The chronic risk quotients for multiple applications of nongranular products of disulfoton are tabulated below. Maximum EECs result from the pesticide being applied repeatedly, but degrading over the course of time from the first application to the last application (FATE program). Average EECs, the average of the estimated daily concentrations over a period of time, were also derived from the FATE program.

Table . Avian Chronic Risk Quotients for Multiple Applications of Non-Granular Disulfoton Based on a Northern bobwhite quail NOEC of 37 ppm.

Site/App Method	App. Rate lbs ai/A (No. of Apps.)/Appl interval	Food Items	Maximum EEC[1] (ppm)	Average 60 day EEC[1] (ppm)	NOEC (ppm)	Average Chronic RQ (Ave. EEC/ NOEC)	Maximum Chronic RQ (Max. EEC/ NOEC)
Potatoes/ ground	4 (2)/14 days	Short grass	1475	655	37	17.70 a	39.86 a
		Tall grass	677	277	37	7.49 a	18.30 a
		Broadleaf plants/Insects	830	369	37	9.97 a	22.43 a
		Seeds	92	57	37	1.54 a	2.49 a
Cotton/ foliar	2 (2)/21 days	Short grass	669	319	37	8.62 a	18.08 a
		Tall grass	307	146	37	3.94 a	8.30 a
		Broadleaf plants/Insects	376	180	37	4.86 a	10.16 a
		Seeds	42	20	37	0.54	1.14 a
Pecans/ aerial	1 (3)/14 days	Short grass	438	233	37	6.30 a	11.84 a
		Tall grass	201	99	37	2.68 a	5.43 a
		Broadleaf plants/Insects	246	131	37	3.54 a	6.65 a
		Seeds	27	19	37	0.51	0.73
Sorghum/ground	1(2)/14 days	Short grass	369	164	37	4.51 a	9.97 a
		Tall grass	169	75	37	2.02 a	4.57 a
		Broadleaf plants/Insects	208	92	37	2.49 a	5.62 a

Table . Avian Chronic Risk Quotients for Multiple Applications of Non-Granular Disulfoton Based on a Northern bobwhite quail NOEC of 37 ppm.							
Site/App Method	App. Rate lbs ai/A (No. of Apps.)/Appl interval	Food Items	Maximum EEC[1] (ppm)	Average 60 day EEC[1] (ppm)	NOEC (ppm)	Average Chronic RQ (Ave. EEC/ NOEC)	Maximum Chronic RQ (Max. EEC/ NOEC)
		Seeds	14	10	37	0.27	0.38
Sorghum/foliar	0.5(3)/14 days	Short grass	219	117	37	3.16 a	5.92 a
		Tall grass	100	54	37	1.46 a	2.70 a
		Broadleaf plants/Insects	124	66	37	1.78 a	3.35 a
		Seeds	14	7	37	0.19	0.38

1 Assumes degradation using FATE program.
a=chronic high-risk LOC has been exceeded.

Based on both the maximum and average EECs, which assumed degradation using the FATE program, the avian chronic level of concern is exceeded by residues on grasses and broadleaf plants and insects for all modeled uses. The maximum residues on seeds also exceeds the avian chronic level of concern for multiple applications at rates equal to or greater than 2 lb ai/A..

Birds may be exposed to granular pesticides ingesting granules when foraging for food or grit. They also may be exposed by other routes, such as by walking on exposed granules or drinking water contaminated by granules. The number of lethal doses (LD50s) that are available within one square foot immediately after application (LD50s/ft$^{2)}$ is used as the risk quotient for granular/bait products. Risk quotients are calculated for three separate weight class of birds: 1000 g (*e.g.*, waterfowl), 180 g (*e.g.*, upland gamebird), and 20 g (*e.g.*, songbird).

The acute risk quotients for broadcast applications of granular products are tabulated below.

Table . Avian Acute Risk Quotients for Granular Products (Broadcast) Based on a Mallard LD50 of 6.54 mg/kg .				
Site/ Application Method/Rate in lbs ai/A	% (decimal) of Pesticide Left on the Surface	Body Weight (g)	LD50 (mg/kg)	Acute RQ[1] (LD50/ft^2)
Sorghum or Barley/Broadcast, unincorporated				
1	1.0	20	6.54	79.51 a
1	1.0	180	6.54	8.83 a
1	1.0	1000	6.54	1.59 a

[1] RQ = App. Rate (lbs ai/A) * (453,590 mg/Lbs/43,560 ft^2/A)
LD50 mg/kg * Weight of Animal (g) * 1000 g/kg
a=high risk, restricted use and endangered species LOCs have been exceeded
b=restricted use and endangered species LOCs have been exceeded
c=endangered species LOC has been exceeded

The results indicate that for broadcast applications of granular products, avian acute high risk, restricted use, and endangered species levels of concern are exceeded at registered maximum application rates equal to or above 1.0 lb ai/A.

The acute risk quotients for banded or in-furrow applications of granular products are tabulated below.

Table . Avian Acute Risk Quotients for Granular Products (Banded or In-furrow) Based on a Mallard LD50 of 6.54 mg/kg .						
Site/Method oz.ai/1000 ft of Row	Band width (ft)	Bird Type and Body Weight (g)	% (decimal) of Pesticide Left on the Surface	Exposed mg/ft^2	LD50 (mg/kg)	Acute RQ[1] (LD50/ft^2)
Tobacco/ Banded-Incorporated						
6.0	0.5	Songbird (20)	0.15	51.03	6.5	392.54 a

Table . Avian Acute Risk Quotients for Granular Products (Banded or In-furrow) Based on a Mallard LD50 of 6.54 mg/kg .						
Site/Method oz.ai/1000 ft of Row	Band width (ft)	Bird Type and Body Weight (g)	% (decimal) of Pesticide Left on the Surface	Exposed mg/ft^2	LD50 (mg/kg)	Acute RQ[1] (LD50/ft^2)
6.0	0.5	Upland Gamebird (180)	0.15	51.03	6.5	43.61a
6.0	0.5	Waterfowl (1000)	0.15	51.03	6.5	7.85a
Potatoes/I n-furrow						
3.45	0.5	Songbird (20)	0.15	29.34	6.5	225.70 a
3.45	0.5	Upland gamebird (180)	0.15	29.34	6.5	25.08 a
3.45	0.5	Waterfowl (1000)	0.15	29.34	6.5	4.51 a
Vegetables (cole crops, etc.)/ banded, incorporated						
1.1	0.5	Songbird (20)	0.15	9.36	6.5	72.23 a
1.1	0.5	Upland Gamebird (180)	0.15	9.36	6.5	8.00 a
1.1	0.5	Waterfowl (1000)	0.15	9.36	6.5	1.44 a

[1] RQ = oz. ai per 1000 ft.* 28349 mg/oz * % Unincorporated / bandwidth (ft) * 1000 ft
LD50(mg/kg) * Weight of the Animal (g)*1000 (g/kg
a=high risk, restricted use and endangered species LOCs have been exceeded
b=restricted use and endangered species LOCs have been exceeded
c=endangered species LOC has been exceeded

The results indicate that avian acute high, restricted use, and endangered species levels of concern are exceeded for banded/in-furrow applications of granular products at registered maximum application rates equal to or above 1.1 oz ai/A.

ii. Mammals

Acute risk

Estimating the potential for adverse effects to wild mammals is based upon EEB's draft 1995 SOP of mammalian risk assessments and methods used by Hoerger and Kenaga (1972) as modified by Fletcher *et al.* (1994). The concentration of disulfoton in the diet that is expected to be acutely lethal to 50% of the test population (LC50) is determined by dividing the LD50 value (usually rat LD50) by the percent of body weight consumed. A risk quotient is then determined by dividing the EEC by the derived LC50 value. Risk quotients are calculated for three separate weight classes of mammals (15, 35, and 1000 g), each presumed to consume four different kinds of food (grass, forage, insects, and seeds). The acute risk quotients for broadcast applications of nongranular products are tabulated below:

Table . Mammalian (Herbivore/Insectivore) Acute Risk Quotients for Single Application of Nongranular Products (Broadcast) Based on a Rat LD50 of 1.9 mg/Kg.

Site/ App. Method/ Rate in lbs ai/A	Body Wt (g)	% Body Wt Cons	Rat LD50 mg/kg	EEC Short Grass	EEC Forage & Small Insects	EEC Large Insects	Acute RQ Short Grass	Acute RQ Forage & Small Insects	Acute RQ Large Insects
Tobacco									
4	15	95	1.9	340	180	28	170.00a	90.00a	14.00a
4	35	66	1.9	340	180	28	118.11a	62.53a	9.73a
4	1000	15	1.9	340	180	28	26.84a	14.21a	2.21a
Beans									
2	15	95	1.9	170	90	14	85.00a	45.00a	7.00a
2	35	66	1.9	170	90	14	58.62a	31.25a	4.86a
2	1000	15	1.9	170	90	14	13.42a	7.10a	1.10a
Broccoli/ wheat									
1	15	95	1.9	85	45	7	42.50a	22.50a	3.50a
1	35	66	1.9	85	45	7	29.51a	15.62a	2.43a
1	1000	15	1.9	85	45	7	6.71a	3.55a	0.55a

[1] RQ = $\frac{\text{EEC (mg/kg)}}{\text{LD50 (mg/kg)/ \% Body Weight Consumed}}$

a=high risk, restricted use and endangered species LOCs have been exceeded

For all single applications at rates greater than 1 lb ai/A, high-risk acute RQs for all size classes of herbivorous/insectivorous mammals consuming grasses, forage, and insects, the LOC for presumption of high acute risk, 0.2, the LOC for restricted use, and 0.1, the LOC for presumption of risk to endangered species. This indicates that use of disulfoton at application rates greater than 1.0 lb poses an acute risk to mammals, both endangered and non-endangered.

Table . Mammalian (Granivore) Acute Risk Quotients for Single Application of Nongranular Products (Broadcast) Based on a rat LD50 of 1.9 mg/kg.

Site/ Application Method/Rate in lbs ai/A	Body Weight (g)	% Body Weight Consumed	Rat LD50 (mg/kg)	EEC Seeds	Acute RQ Seeds
Tobacco					
4	15	21	1.9	28	14.00a
4	35	15	1.9	28	9.72a
4	1000	3	1.9	28	2.21a
Beans					
2	15	21	1.9	14	7.00a
2	35	15	1.9	14	4.86a
2	1000	3	1.9	14	1.10a
Broccoli/ Wheat					
1	15	21	1.9	7	3.50a
1	35	15	1.9	7	2.43a
1	1000	3	1.9	7	0.55a

[1] RQ = $\frac{\text{EEC (mg/kg)}}{\text{LD50 (mg/kg)/ \% Body Weight Consumed}}$

a=high risk, restricted use and endangered species LOCs have been exceeded

The results indicate that for single applications of disulfoton at application rates greater than or equal to 1 lb ai/A, the acute high-risk level of concern has been exceeded for all size classes of granivorous mammals consuming seeds.

Table . Mammalian (Herbivore/Insectivore) Acute Risk Quotients Multiple Applications of Nongranular Products (Broadcast) Based on a rat LD50 of 1.9 mg/kg.

Site/ App. Method/ Rate in lbs ai/A (No. of Apps.)	Body Weight (g)	% Body Weight Consumed	Rat LD50 mg/kg	EEC Short Grass	EEC Forage & Small Insects	EEC Large Insects	Acute RQ Short Grass	Acute RQ Forage & Small Insects	Acute RQ Large Insects
Potatoes/ground									
4 (2)	15	95	1.9	1475	830	92	737.5a	415.0a	46.0a
4 (2)	35	66	1.9	1475	830	92	512.2a	288.2a	31.9a
4 (2)	1000	15	1.9	1475	830	92	116.4a	65.1a	7.3a
Pecans/ aerial									
1 (3)	15	95	1.9	438	246	27	219.0a	123.0a	13.5a
1 (3)	35	66	1.9	438	246	27	152.1a	85.4a	9.4a
1 (3)	1000	15	1.9	438	246	27	34.6a	19.4a	2.1a
Cotton/foliar									
2 (2)	15	95	1.9	669	376	42	334.5a	188.0a	21.0a
2 (2)	35	66	1.9	669	376	42	232.3a	130.6a	14.6a
2 (2)	1000	15	1.9	669	376	42	52.8a	29.7a	3.3a
Sorghum/ground									
1 (2)	15	95	1.9	369	208	23	184.5a	104.0a	11.5a
1 (2)	35	66	1.9	369	208	23	128.1a	72.2a	8.0a
1 (2)	1000	15	1.9	369	208	23	29.1a	16.4a	1.8a
Sorghum/foliar									
0.5 (3)	15	95	1.9	219	123	14	109.5a	61.5a	7.0a
0.5 (3)	35	66	1.9	219	123	14	76.0a	42.7a	4.9a
0.5 (3)	1000	15	1.9	219	123	14	17.3a	9.7a	1.1a

[1] $RQ = \frac{EEC\ (mg/kg)}{LD50\ (mg/kg) / \%\ Body\ Weight\ Consumed}$

a=high risk, restricted use and endangered species LOCs have been exceeded

Table . Mammalian (Granivore) Acute Risk Quotients for Multiple Applications Nongranular Products (Broadcast) Based on a rat LD50 of 1.9 mg/kg.

Site/ App. Method/ Rate in lbs ai/A (No. of Apps.)	Body Weight (g)	% Body Weight Consumed	Rat LD50 (mg/kg)	EEC Seeds	Acute RQ Seeds
Potatoes/ground					
4 (2)	15	21	1.9	92	46.00a
4 (2)	35	15	1.9	92	31.94a
4 (2)	1000	3	1.9	92	7.26a
Pecans/aerial					
1 (3)	15	21	1.9	27	13.50a
1 (3)	35	15	1.9	27	9.38a
1 (3)	1000	3	1.9	27	2.13a
Cotton/foliar					
2 (2)	15	21	1.9	42	21.00a
2 (2)	35	15	1.9	42	14.58a
2 (2)	1000	3	1.9	42	3.31a
Sorghum/ground 1 (2)	15	21	1.9	23	11.50a
1 (2)	35	15	1.9	23	7.99a
1 (2)	1000	3	1.9	23	1.82a
Sorghum/foliar					
0.5 (3)	15	21	1.9	14	7.00a
0.5 (3)	35	15	1.9	14	4.86a
0.5 (3)	1000	3	1.9	14	1.10a

[1] RQ = $\frac{\text{EEC (mg/kg)}}{\text{LD50 (mg/kg)/ \% Body Weight Consumed}}$

a=high risk, restricted use and endangered species LOCs have been exceeded

The results indicate that for multiple applications of nongranular products, mammalian acute high risk LOCs are exceeded for at application rates greater than or equal to 0.5 lbs ai/A.

Chronic Risk

The chronic risk quotients for broadcast applications of nongranular products are tabulated below:

Table . Mammalian Chronic Risk Quotients for Single and Multiple Applications of Nongranular Disulfoton Based on a rat NOEC of 0.8 ppm in a 2-generation reproduction study.

Site/Application Method	Application Rate in lbs ai/A (No. of Apps.)	Food Items	Average EEC[1] (ppm)	NOEC (ppm)	Chronic RQ (EEC/NOEC)
Potatoes ground	4 (2)	Short grass	655	0.8	818.75a
		Tall grass	277	0.8	346.25a
		Broadleaf plants/Insects	369	0.8	461.25a
		Seeds	57	0.8	71.25a
Cotton foliar	2 (2)	Short grass	319	0.8	398.75a
		Tall grass	146	0.8	182.50a
		Broadleaf plants/Insects	180	0.8	225.00a
		Seeds	20	0.8	25.00a
Sorghum ground	1 (2)	Short grass	164	0.8	205.00a
		Tall grass	75	0.8	93.75a
		Broadleaf plants/Insects	92	0.8	115.00a
		Seeds	10	0.8	12.50a
Vegetables ground	1 (1)	Short grass	30	0.8	37.50a
		Tall grass	14	0.8	17.50a
		Broadleaf plants/Insects	16	0.8	20.00a
		Seeds	2	0.8	2.50a

a=high risk LOC has been exceeded

The above results indicate that for broadcast applications of nongranular products, the chronic level of concern for small mammals is exceeded at registered application rates equal to or above 1.0 lbs ai/A.

iii. Insects

Currently, EFED does not assess risk to nontarget insects. Results of acceptable studies are used for recommending appropriate label precautions. Disulfoton and its sulfoxide and sulfone metabolites are classified as highly toxic to the honeybee on an acute contact and oral basis, therefore, appropriate toxicity label language is required. Current labeling includes the appropriate bee toxicity warning statement.

B. Risk to Nontarget Freshwater Aquatic Animals

Tier II estimated environmental concentrations (EECs) for a variety of disulfoton applications were calculated to generate aquatic exposure estimates for use in the ecological risk assessment.

I. Freshwater Fish

Acute and chronic risk quotients are tabulated below.

Table . Acute Risk Quotients for Freshwater Fish Based On a Bluegill Sunfish LC50 of 39 ppb (most sensitive species). EECs are from PRZM/EXAMS.

Site/Rate in lbs ai/A (No. of Apps.), inches incorporated	LC50 (ppb)	EEC Initial/Peak (ppb)	Acute RQ (EEC/LC50)
Barley --aerial, 0.82 (2),0	39	18.02	0.46 b
ground, 1.0 (2),0		17.92	0.46 b
Cotton --ground, 3.27 (3), 2.5	39	54.24	1.39 a
ground, 1.01 (3), 2.5		16.75	0.43 b
Potatoes--ground, 9.4 (2), 0	39	117.00	3.00 a
ground, 9.4 (2),2.5		51.78	1.33 a
ground, 4.0(2),0		49.76	1.28 a
Tobacco--ground, 8.17 (1),2.5	39	98.19	2.52 a
ground, 16.3 (1), 2.5		85.02	2.18 a
ground, 4.0 (1), 2.5		20.85	0.53 a
Sp. Wheat--aerial, 0.64 (1), 0	39	10.20	0.26 b
ground, 1.0 (1), 0		7.90	0.20 b

a=high risk, restricted use and endangered species LOC s have been exceeded
b=restricted use and endangered species LOCs have been exceeded
c=endangered species LOC has been exceeded

The results indicate that the aquatic acute high risk level of concern is exceeded by multiple applications at rates greater than or equal to 3.2 lb ai/A, and single applications at rates greater than or equal to 4.0 lb ai/A .

Table . Chronic Risk Quotients for Freshwater Fish Based On a Rainbow Trout NOEC of 220 ppb and an Estimated Bluegill Sunfish NOEC[1] of 2.7 ppb .

Site/Rate in lbs ai/A (No. of Apps.)	Estimated Bluegill NOEC (ppb)	Rainbow Trout NOEC (ppb)	EEC 60-Day (ppb)	Chronic RQ Based on Bluegill estimated NOEC (EEC/NOEC)	Chronic RQ based on Trout NOEC (EEC/NOEC)
Barley --aerial, 0.82 (2),0	2.7	220	14.75	5.5 a	0.07
ground, 1.0 (2),0			13.95	5.2 a	0.06
Cotton --ground, 3.27 (3), 2.5	2.7	220	43.35	16.0 a	0.20
ground, 1.01 (3), 2.5			13.39	5.0 a	0.06
Potatoes--ground, 9.4 (2), 0	2.7	220	93.54	34.6 a	0.42
ground, 9.4 (2),2.5			41.69	15.4 a	0.19
ground, 4.0(2),0			39.84	14.8 a	0.18
ground, 4.0 (2), 2.5			17.78	6.6 a	0.08
Tobacco--ground, 8.17 (1),2.5	2.7	220	75.11	27.8 a	0.34
ground, 16.3 (1), 2.5			64.00	23.7 a	0.29
ground, 4.0 (1), 2.5			15.70	5.8 a	0.07
Sp. Wheat--aerial, 0.64 (1), 0	2.7	220	8.32	3.1 a	0.04
ground, 1.0 (1), 0			6.03	2.2 a	0.03

[1] There is a substantial difference in sensitivity between the bluegill sunfish (LC_{50} =39 ppb) and the rainbow trout (LC_{50}=3000 ppb). The only freshwater fish chronic data available for disulfoton was for the rainbow trout; therefore, an estimated early life-stage NOEC was calculated for the bluegill using the chronic to acute ratio for rainbow trout (220 ppb/3000 ppb = 0.07). The bluegill LC_{50} was multiplied by this number to obtain the estimated NOEC (39 x 0.07 = 2.7 ppb).
a= high risk LOC has been exceeded

Using the estimated bluegill NOEC, the results indicate that the aquatic chronic level of concern is exceeded for disulfoton at application rates of greater than or equal to 0.64 lb ai/A. Using the rainbow trout NOEC, the chronic level of concern is not exceeded by application rates up to and including 9.4 lb ai/A.

ii. Freshwater Invertebrates

The acute and chronic risk quotients are tabulated below.

Table . Risk Quotients for Freshwater Invertebrates Based on a daphnia magna LC50 of 13 ppb and a NOEC OF 0.037 ppb.

Site/Rate in lbs ai/A (No. of Apps.), inches incorporated	LC50 (ppb)	NOEC (ppb)	EEC Initial/Peak (ppb)	EEC 21-Day (ppb)	Acute RQ (EEC/LC50)	Chronic RQ (EEC/NOEC)
Barley--aerial, 0.83 (2),0	13	0.037	18.02	16.50	1.34 a	445.94a
Barley-- ground, 1.0 (2),0			17.92	15.85	1.38 a	428.38a
Cotton--ground, 3.27 (3), 2.5	13	0.037	54.24	48.54	4.17 a	1,311.89a
Cotton-- ground, 1.01 (3), 2.5			16.75	14.98	1.29 a	404.86a
Potatoes--ground, 9.4 (2), 0	13	0.037	117.00	106.50	9.00 a	2,878.38a
Potatoes--ground, 9.4 (2),2.5			51.78	47.39	3.98 a	1,280.91a
Potatoes-- ground, 4.0(2),0			49.76	45.44	3.83 a	1,228.11a
Potatoes--ground 4.0 (2),2.5			22.08	20.21	1.70 a	546.22a
Tobacco--ground, 8.17 (1),2.5	13	0.037	98.19	87.30	7.55 a	2,359.66a
Tobacco-- ground, 16.3 (1), 2.5			85.02	74.36	6.54 a	2,009.73a
Tobacco-- ground, 4.0 (1), 2.5			20.85	18.24	1.20 a	493.78a
Sp.wheat---aerial, 0.64 (1), 0	13	0.037	10.20	9.44	0.78 a	349.63a
Sp.wheat-- ground, 1.0 (1), 0			7.90	7.08	0.61 a	191.35a

a=high risk, restricted use and endangered species LOCs have been exceeded
b=restricted use and endangered species LOCs have been exceeded
c=endangered species LOC has been exceeded

The results indicate that the aquatic acute high risk level of concern has been exceeded for freshwater invertebrates at application rates equal to or greater than 0.6 lb ai/A. The chronic level of concern has been greatly exceeded for application rates of equal to or greater than 0.6 lb ai/A.

Soil incorporation reduces the risk to freshwater invertebrates, but does not eliminate it.

C. Exposure and Risk to Nontarget Estuarine and Marine Animals

I. Fish

The acute and chronic risk quotients for estuarine and marine fish are tabulated below.

Table . Acute Risk Quotients for Marine/Estuarine Fish Based on a Sheepshead Minnow LC50 of 520 ppb.

Site/Rate lbs ai/A (No. of Apps.)	LC50 (ppb)	EEC Initial/Peak (ppb)	Acute RQ (EEC/LC50)
Barley--aerial, 0.83 (2),0	520	18.02	0.03
Barley-- ground, 1.0 (2),0		17.92	0.00
Cotton--ground, 3.27 (3), 2.5	520	54.24	0.10 c
Cotton-- ground, 1.01 (3), 2.5		16.75	0.03
Potatoes--ground, 9.4 (2), 0	520	117.0	0.22 b
Potatoes--ground, 9.4 (2),2.5		51.78	0.10 c
Potatoes-- ground, 4.0(2),0		49.76	0.10 c
Potatoes--ground, 4.0(2), 2.5		22.08	0.04
Tobacco---ground, 8.17 (1),2.5	520	98.19	0.10 c
Tobacco-- ground, 16.3 (1), 2.5		85.02	0.16 c
Tobacco--ground, 4.0 (1), 2.5		20.85	0.04

Table . Acute Risk Quotients for Marine/Estuarine Fish Based on a Sheepshead Minnow LC50 of 520 ppb.			
Site/Rate lbs ai/A (No. of Apps.)	LC50 (ppb)	EEC Initial/Peak (ppb)	Acute RQ (EEC/LC50)
Sp. Wheat--aerial, 0.64 (1), 0	520	10.20	0.02
Sp.wheat--ground, 1.0 (1), 0		7.90	0.02

a=high risk, restricted use and endangered species LOCs have been exceeded
b=restricted use and endangered species LOCs have been exceeded
c=endangered species LOC has been exceeded

The results indicate that the aquatic acute restricted use level of concern for marine/estuarine fish is exceeded by multiple applications of 9.4 lb ai/A and greater with no incorporation. The endangered species level of concern has been exceeded by multiple applications greater than 3.27 lb ai/A, with incorporation, and by single applications of 8 lb ai/A and greater, even with incorporation.

Table . Chronic Risk Quotients for Marine/Estuarine Fish Based on a Sheepshead Minnow Early Life-Stage NOEC of 16.2 ppb, and a Life-Cycle NOEC OF 0.96 ppb.						
Site/Rate lbs ai/A (No. of Apps.)	Early Life-Stage NOEC (ppb)	Life-Cycle NOEC (ppb)	EEC 60-Day (ppb)	EEC 90-Day (ppb)	Early Life-stage RQ (60-Day EEC/NOEC)	Life-Cycle RQ (90-Day EEC/NOEC)
Barley	16.2	0.96	14.75	13.56	0.91	14.12a
			13.95	12.59	0.86	13.11a
Cotton	16.2	0.96	43.35	40.91	2.68a	42.61a
			13.39	12.63	0.78	13.16a
Potatoes	16.2	0.96	93.54	85.92	5.77a	89.50a
			39.84	36.59	2.46a	38.11a
			41.69	37.83	2.56a	39.41a
			17.78	16.13	1.10a	16.80a
Tobacco	16.2	0.96	75.11	68.75	4.64a	71.61a
			64.00	58.62	3.96a	61.06a
			15.70	14.38	0.97	14.98a

Table . Chronic Risk Quotients for Marine/Estuarine Fish Based on a Sheepshead Minnow Early Life-Stage NOEC of 16.2 ppb, and a Life-Cycle NOEC OF 0.96 ppb.						
Site/Rate lbs ai/A (No. of Apps.)	Early Life-Stage NOEC (ppb)	Life-Cycle NOEC (ppb)	EEC 60-Day (ppb)	EEC 90-Day (ppb)	Early Life-stage RQ (60-Day EEC/NOEC)	Life-Cycle RQ (90-Day EEC/NOEC)
Sp. Wheat	16.2	0.96	8.32 6.03	7.71 5.51	0.51 0.37	8.03a 5.74a

a=high risk LOC has been exceeded.

The results indicate that the early life-stage chronic level of concern has been exceeded for marine/estuarine fish at mutiple application rates of 1.0 lbs ai/A and greater, and for single application rates of 4 lb ai/A and greater. The life-cycle chronic level of concern has been exceeded at application rates of 0.6 lb ai/A and greater. Soil incorporation reduces, but does not eliminate, the risk to marine/estuarine fish.

ii. Invertebrates

The acute and chronic risk quotients for aquatic invertebrates are tabulated below.

Table . Acute Risk Quotients for Marine/Estuarine Invertebrates Based on a Mysid LC50 of 100 ppb.			
Site/Rate lbs ai/A (No. of Apps.)	LC50 (ppb)	EEC Initial/Peak (ppb)	Acute RQ (EEC/LC50)[1]
Barley	100	18.02 17.92	0.18 c 0.18 c
Cotton	100	54.24 16.75	0.54 a 0.17 c
Potatoes	100	117.0 51.78 49.76 22.08	1.17 a 0.52 a 0.50 a 0.22 b
Tobacco	100	98.19 85.02 20.85	0.98 a 0.85 a 0.21 b
Sp. Wheat	100	10.20 7.90	0.10 c 0.08 c

a=high risk, restricted use and endangered species LOCs have been exceeded

b=restricted use and endangered species LOCs have been exceeded
c=endangered species LOC has been exceeded

The results indicate that the aquatic acute high risk level of concern has been exceeded for marine/estuarine invertebrates for applications of 3.3 lb ai/A and greater, and for single applications of 8 lb ai/A and greater. Soil incorporation reduces the risk to marine/estuarine invertebrates, in some cases to below the high risk level of concern. However, it does not eliminate the risk. The restricted use level of concern is exceeded by applications at rates equal to or greater than 4.0 lb ai/A, with soil incorporation. The endangered species level of concern is exceeded by all applications at 0.6 lb ai/A and greater, regardless of soil incorporation.

Table . Chronic Risk Quotients for Marine/Estuarine Invertebrates Based on a Mysid Life-Cycle NOEC of 2.35 ppb.

Site/Rate lbs ai/A (No. of Apps.)	Early Life-Stage NOEC (ppb)	EEC 21-Day (ppb)	Life-Cycle RQ (21-Day EEC/NOEC)
Barley	2.35	16.50	7.02a
		15.85	6.74a
Cotton	2.35	48.54	20.66a
		14.98	6.37a
Potatoes	2.35	106.50	45.32a
		47.39	20.16a
		45.44	19.34a
		20.21	8.60a
Tobacco	2.35	87.30	37.15a
		74.36	31.60a
		18.24	7.76a
Sp. Wheat	2.35	9.44	4.02a
		7.08	3.01a

a=high risk LOC has been exceeded

The results indicate that the chronic level of concern has been exceeded for marine/estuarine invertebrates for all application scenarios modeled, at rates greater than or equal to 0.64 lb ai/A, regardless of soil incorporation..

D. Exposure and Risk to Nontarget Plants

Although Tier I terrestrial and aquatic plant testing is required for disulfoton due to label phytotoxicity warnings, no data on plant toxicity has been submitted at this time. Therefore, the risk to nontarget plants cannot be assessed.

5. Endangered Species

The following endangered species LOCs have been exceeded for disulfoton: avian acute, avian chronic, mammalian acute, mammalian chronic, freshwater fish acute, freshwater invertebrate acute, freshwater invertebrate chronic, marine/estuarine fish acute, marine/estuarine fish chronic, marine/estuarine invertebrate acute, and marine/estuarine invertebrate chronic. Endangered terrestrial, semi-aquatic and aquatic plants also may be affected, based on label statements indicating phytotoxicity.

The Endangered Species Protection Program is expected to become final in the future. Limitations on the use of disulfoton will be required to protect endangered and threatened species, but these limitations have not been defined and may be formulation specific. EPA anticipates that a consultation with the Fish and Wildlife Service will be conducted in accordance with the species-based priority approach described in the Program. After completion of consultation, registrants will be informed if any required label modifications are necessary. Such modifications would most likely consist of the generic label statement referring pesticide users to use limitations contained in county Bulletins.

6. Disulfoton Incident Reports

There are both bird and fish kills reported for disulfoton. The following are summaries of incidents reported through EIIS, IDS and USFWS personnel.

BIRD INCIDENTS:
1. Young County, TX, 6/18/93. Eighteen Swainson's hawks were found dead and one found severely disabled in a cotton field. The cotton seed had been treated with disulfoton seed treatment prior to planting, about 10 days before the birds were discovered. According to field personnel, no additional applications of organophosphorus or carbamate pesticides had been made in the vicinity of the field. Laboratory analysis of the birds revealed insect material in the gastrointestinal tracts. Residue chemistry analysis of this material indicated the presence of disulfoton; no other organophosphorus or carbamate insecticides were present. Apparently, the hawks had fed on insects, which had been feeding on the young cotton plants. The systemic nature of the pesticide appears to have resulted in plant residues, which were then taken up by the insects, at levels high enough to cause mortality in the hawks. This may be the first documented incident of this type of exposure in a raptor species. (L.Lyon, Div. of Environmental Contaminants, U.S. Fish and Wildlife Service, Arlington, VA. Presented at the SETAC 18th annual meeting, San Francisco, CA, 1997).

2. Sussex County, DE, 4/26/91. Nine American robins found dead following application of granular disulfoton at a tree nursery. Corn and soybeans were also in the vicinity. No laboratory

results were obtained. Certainty index is probable for disulfoton. (Incident Report No. I000116-003).

3. Puerto Rico, 1/24/96. Six grackles fell dead from a tree in the yard of a private residence. A dead heron and a dead owl were also found in the vicinity. The use site and method were not reported. Birds had depressed acetyl cholinesterase. Residue analysis on gut contents of one of the grackles found disulfoton residues of 12.37 ppm wet weight. Certainty index of this incident is highly probable for disulfoton. (Incident Report No. I003966-004).

FISH INCIDENTS

1. Onslow County, NC, 6/22/91. A fish kill occurred in a pond at a private residence. The pond received runoff from a neighboring tobacco field. Analysis of the water in the pond revealed the presence of disulfoton and several other pesticides, including endosulfan. Disulfoton sulfoxide was found in the water at a concentration of 0.32 ppb. Endosulfan had the highest concentration (1.2 μg/L), and is toxic to fish, but disulfoton cannot be ruled out as a possible cause of death. No tissue analysis was conducted. The certainty index of this incident for disulfoton is “possible.” (Incident Report No. B0000216-025).

2. Onslow County, NC, 4/29/91. A fish kill occurred in a pond, which was adjacent to a tobacco field and a corn field. Rain followed the application of pesticide, and more than 200 dead fish were found floating in the pond. Water and soil samples were collected within a week after the incident. Several organophosphorus pesticides, as well as atrazine and napromide, were found in all soil samples taken from around the pipe that ran from the field to the pond, but none of the samples contained detectable disulfoton. The pesticide applicator failed to follow packaging guidance on safe handling of the pesticides. Additionally, the corn and tobacco fields were 62-82 feet uphill from the pond, which violates the requirement that these pesticides not be applied within 140 feet of a waterway. The certainty index for this incident is “unlikely” for disulfoton (Incident Report No. I000799-004).

3. Johnston County, NC, 6/12/95. A fish kill occurred in a commercial fish pond. Crop fields nearby had been treated with pesticides. Water, soil and vegetation samples were taken and analyzed for a variety of pesticides. Disulfoton, as well as several other pesticides was found in the samples. The level of disulfoton in the vegetation samples was 0.2-2.5 ppm. The certainty index for this incident is “possible” for disulfoton. (Incident Report No. I003826-002).

4. Arapahoe County, CO, 6/14/94. A fish kill occurred following application of Di-Syston 8EC to wheat, which was followed by a heavy rain. Water samples collected contained disulfoton sulfoxide at levels of 29.5-48.7 ppb, and disulfoton sulfone at 0.0199-0.214 ppb. (Incident Report No. I001167-001).

These incident reports document the potential for disulfoton products to cause adverse acute impacts to birds and fish in the field. The presumption of risk to these classes of organisms, indicated by the risk assessment, is supported by these incident reports.

7. Risk Characterization

A. Characterization of the Fate and Transport of Disulfoton

I. Drinking water

(a) Surface Water

The fate of disulfoton in surface water and the likely concentrations cannot be modeled with a high degree of certainty since no data are available for the aerobic and anaerobic aquatic degradation rates, and anaerobic soil metabolism. The large degree of latitude available in the disulfoton labels also allows for a wide range of possible application rates, total amounts, application methods, and intervals between applications. Considering the relatively rapid rate of microbial degradation in the soil (<20 day aerobic soil metabolism half-life) and direct aquatic photolysis, disulfoton parent may degrade fairly rapidly in surface water. However, peak concentrations appear capable of being quite high, with peak surface water concentrations of 7.90 to 117.00 μg/L and 90-day concentrations of 5.52 to 85.92 μg/L for the parent compound. By not adequately considering aquatic degradation, the cotton scenario suggest an accumulation of disulfoton (so decline after peak). Although no assessment can be made for degradates due to lack of data, limited data suggests that the degradates are more persistent (>200 days) than disulfoton, suggesting their presence in water for a longer period of time than the parent. The degradates also appear to be more mobile than the parent compound.

A search of the EPA's STORET (10/16/97) data base resulted in the identification of disulfoton residues at a number of locations. The detected values ranged from 0.01 to 100.0 μg/L; however, most of the values were reported as "actual value is less than this value." Thus, when a value of 100.00 µg/L is reported, it is not known how much less than 100.0 μg/A the actual value is..

Surface-water monitoring by the USGS in the NAWQA (USGS, 1997) project found relatively few detections of disulfoton in surface water with a maximum concentration of 0.041 µg/L.

(b) Ground Water

The SCI-GROW (Screening Concentration in Ground Water) screening model developed in EFED (Barrett, 1997) was used to estimate potential ground water concentrations for disulfoton parent under hydrologically vulnerable conditions. The maximum disulfoton ground water concentration predicted by the SCI-GROW using the maximum rate (for potatoes, 2 applications at 9.4 lb ai/A with a 14-day interval) was 0.83 µg/L.

Ground water monitoring data generally confirms fairly rapid degradation, because relatively few low level detections of disulfoton parent in ground water. The PGWDB (USEPA, 1992) reported disulfoton residues ranging from 0.04 to 100.00 µg/L were reported in Virginia and Wisconsin.

The study reference with the 100.00 µg/L detection (in Wisconsin) could not be found, but would appear to be an anomalous value or point source. There were no ground-water detections of parent disulfoton in the USGS NAWQA (USGS, 1997) with a limit of detection of 0.01 or 0.05µg/L, depending upon method. Some notable limitations of modeling and monitoring were presented elsewhere in this document.

Although no assessment can be made for degradates due to lack of data, limited data suggests that the degradates are more persistent (>200 days) than disulfoton, suggesting their presence in water for a longer period of time than the parent. The degradates also appear to be more mobile than the parent compound.

Ground water monitoring data tends to confirm fairly rapid degradation, but potentially high peak values. The majority of samples had low levels (<16 µg/L) of disulfoton residues. There were indications of some high concentrations, but this may be a reflection of how the data were reported as the actual disulfoton concentrations in the monitoring were not always known. This is because the detection limit was not adequate (extremely high) or specified, and/or the limit of quantification was not stated or extremely high. Disulfoton concentrations were simply given as less than a value. Therefore, considerable uncertainty exists with respect to the monitoring data . Although no assessment can be made for degradates due to lack of data, limited data suggests that the degradates are more persistent (>200 days) than disulfoton, suggesting their presence in water for a longer period of time than the parent. The degradates also appear to be more mobile than the parent compound.

B. Characterization of risk to nontarget species from Disulfoton

Birds: The overall **acute** risk to birds is high for most of the label application rates and methods for the liquid formulations of disulfoton. Even the lowest application rate (0.5 lb ai/A) still exceeds the restricted use level of concern when it is applied 3 times per year as permitted by the label. The granular formulations of disulfoton also present high acute risk to birds, especially from banded applications. In-furrow applications present somewhat less risk to birds due to the lowered exposure to the actual granules, but the high-risk level of concern is still exceeded. Since disulfoton is systemic, birds can still be exposed to toxic levels of the pesticide in plant tissues and in insects that feed on the plant tissues. One bird-kill incident was found to be caused by this route of exposure (L. Lyon, SETAC, 1997). The sulfone and sulfoxide degradates of disulfoton are persistent (half-lives of up to 367 days), and exhibit comparable avian acute toxicity to parent disulfoton. Because of this, there is the potential for adverse effects to birds for a prolonged period of time following even a single application. Several incident reports of bird kills support the presumption of acute risk to birds. Terrestrial field testing also confirmed the potential of disulfoton to kill birds in the field.

Chronic risk to birds is also expected from exposure to disulfoton. Average residues exceed the avian chronic level of concern for application rates greater than or equal to a single application at

1 lb ai/A. As with the acute risk, the chronic risk is increased by the persistence of the sulfone and sulfoxide degradates. Since many of the applications of disulfoton occur in the spring, overlapping the breeding season for most bird species, there is the potential for significant reproductive impacts.

<u>Mammals:</u> The overall **acute** risk to mammals is expected to be high. All modeled application rates and methods exceed the high risk acute level of concern for mammals, regardless of the mammals' size and diet composition. Since disulfoton is a systemic pesticide, the granular formulations can result in exposure through food items due to uptake by the plant tissues in addition to direct exposure to any unincorporated granules. Applications of the liquid formulations of disulfoton also result in direct exposure and exposure in food items. The persistent sulfone and sulfoxide degradates are also toxic to mammals, thereby increasing the potential risk from the application of disulfoton. The Incident Data System (IDS) contains numerous domestic animal injury and death incidents, including deaths of large mammals such as horses and cattle. Small mammal carcasses were also found during terrestrial field testing of disulfoton on potatoes, confirming the presumption of acute risk to mammals.

Chronic risk to mammals is expected as well. All modeled application rates and methods exceed the chronic high risk level of concern for mammals. The persistence of the sulfone and sulfoxide degradates, which are also toxic to mammals, increases the likelihood of chronic risk to mammals.

<u>Non-target Insects</u>: Disulfoton and its sulfoxide and sulfone degradates are very highly toxic to bees, so it is likely that bees, as well as other non-target and beneficial insects, would be harmed if exposed to disulfoton in the field.

<u>Freshwater Fish</u>: The overall **acute** risk to freshwater fish is expected to be high. Three of the five crop scenarios modeled resulted in exceedance of the high acute risk level of concern, with the remaining two scenarios exceeding the restricted use and endangered species levels of concern. Several kills of freshwater fish have occurred from applications of disulfoton to different crops, from registered uses as well as from misuse. There is, however, a large amount of variation in freshwater fish species' sensitivity to disulfoton, as evidenced in the toxicity data table. There are also incident reports of several fish kills from disulfoton use, supporting the presumption of acute risk to fish.

Chronic risk to freshwater fish is expected from the use of disulfoton. The single freshwater fish species (rainbow trout) for which chronic toxicity data was available demonstrates significantly less sensitivity to disulfoton than several other species (bluegill sunfish, bass, guppy). Therefore, an estimated chronic NOEC value was calculated using the chronic to acute ratio for the rainbow trout, as described earlier.

Freshwater Invertebrates: The overall **acute** risk to freshwater invertebrates is expected to be high. All the modeled crop scenarios exceeded the high risk level of concern. Again, the risk is further increased due to the toxicity and persistence of the degradates of disulfoton.

Chronic risk to freshwater invertebrates is expected from the use of disulfoton. All of the modeled crop scenarios greatly exceeded the high risk level of concern, sometimes by a factor of several thousand. Invertebrate life-cycle testing with disulfoton shows that it impacts reproductive parameters (number of young produced by adults) in addition to survival and growth.

Estuarine and Marine Fish: The overall **acute** risk to estuarine and marine fish is not expected to be high; however, the endangered species level of concern was exceeded by several of the modeled crop scenarios (cotton, potatoes and wheat). As noted above, there can be substantial species differences in sensitivity to disulfoton. Therefore, it is possible that the single marine/estuarine fish species tested (Sheepshead minnow) does not fully represent the true range of sensitivity found in a marine or estuarine ecosystem, and this assessment may therefore underestimate the true risk to marine/estuarine fish. There is also some uncertainty in using the PRZM/EXAMs EECs to predict exposure to marine/estuarine organisms. The scenarios modeled are based on data for freshwater habitats. The exposure in a marine or estuarine habitat may be higher or lower than that predicted for a freshwater habitat, resulting in higher or lower risk to marine/estuarine organisms.

Chronic risk to estuarine and marine fish is expected from the use of disulfoton. Both early life-stage and full life-cycle testing demonstrated a variety of effects at low levels of disulfoton. Risk quotients based on the early life-stage toxicity endpoint exceeded the level of concern for cotton, potatoes and tobacco, and risk quotients based on the life-cycle toxicity endpoint exceeded the level of concern for all modeled scenarios.

Estuarine and Marine Invertebrates: The overall **acute** risk to marine and estuarine invertebrates is expected to be high. Three of the five modeled scenarios (cotton, potatoes, and tobacco) resulted in exceedance of the estuarine/marine invertebrate high risk level of concern. There is some uncertainty, however, in using the PRZM/EXAMs EECs to predict exposure to marine/estuarine organisms. The scenarios modeled are based on data for freshwater habitats. The exposure in a marine or estuarine habitat may be higher or lower than that predicted for a freshwater habitat, resulting in higher or lower risk to marine/estuarine organisms.

Chronic risk to marine/estuarine invertebrates is expected. All of the modeled crop scenarios exceeded the chronic level of concern.

Nontarget Plants: Currently, terrestrial and aquatic plant testing is not required for pesticides other than herbicides except on a case-by-case basis. Nontarget plant testing was not required for disulfoton, so the risk to plants could not be assessed at this time. There are phytotoxicity statements on the label, however, as well as some incident reports of possible plant damage from the use of disulfoton, so there is the potential for risk to nontarget plants.

C. Mitigation

There is a large amount of latitude in the disulfoton labeling regarding application rates, numbers of applications, row spacing and application methods. This risk assessment was based primarily on those parameters that resulted in maximum environmental concentrations, and, therefore, maximum potential exposure of wildlife and aquatic organisms. Reducing the maximum application rates allowed on the label to those rates most typically used by the grower would lower the risk. Likewise, labeling permitting fewer applications per season or requiring longer application intervals would also lower the risk to nontarget organisms. Information from the registrants indicates that most uses of disulfoton are in-furrow applications; requiring in-furrow applications would reduce the risk from the broadcast applications modeled in this assessment.

Incorporating standard labeling language for ground water contamination and bee mitigation would also help reduce risk. The following labeling language is appropriate for groundwater: "This chemical is known to leach through soil into ground water under certain conditions as a result of label use. Use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in ground water contamination."

For mitigating the hazard to bees, the following labeling statement is appropriate: "This product is toxic to bees exposed to direct treatment or residues on blooming crops or weeds. Do not apply this product if bees are visiting the treatment area."

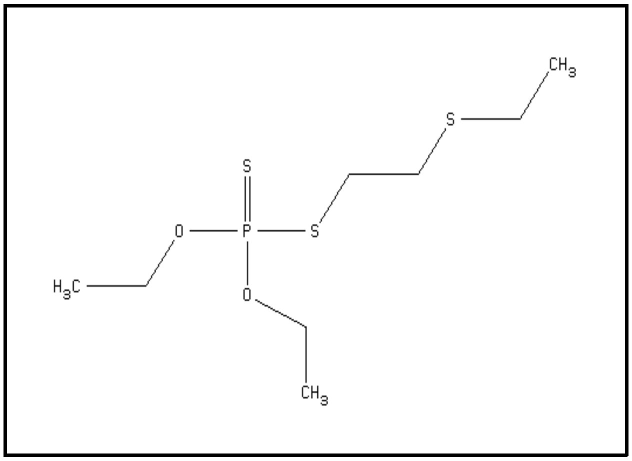
APPENDIX I: USE OF DISULFOTON (LB AI/YR) BY CROP AND BY STATE

Crop	Percent of market	lb ai/yr (Doane's Agriculture Service data)	lb ai/yr (estimate provided by BEAD, based on market information)
Cotton	61	428,000	420,000-840,000
Wheat	16	123,000	180,000-354,000
Barley	7	49,000	29,000-77,000
Potatoes	7	50,000	120,000-195,000
Peanuts	5	27,000	47,000-106,000
Cole crops	2	14,000	no information
Corn	1	4,000	36,000-73,000
Tobacco	1	4,000	64,000-128,000

State	Percent of market	lb ai/yr (based on total ai/yr of 1,700,000 lb)
California	16	272,000
Louisiana	11	187,000
Kentucky	10	170,000
Missouri	8	136,000
Arkansas	8	136,000
Texas	7	119,000
Alabama	7	119,000
Virginia	6	102,000
North Carolina	5	85,000
Maine	4	68,000
Mississippi	4	68,000
Utah	4	68,000
Georgia	3	51,000
Michigan	2	34,000
Ohio	2	34,000
Arizona	1	17,000

New Mexico	1	17,000

APPENDIX II: Chemical Structure of Disulfoton



APPENDIX III

I. Tier I Water Resource Assessment.

This section presents a preliminary assessment of the potential to contaminate ground water and surface water from labeled uses of disulfoton and to obtain to initial estimates of environmental concentrations of disulfoton in surface water bodies for use in the human health and ecological risk assessment as part of the registration process. The assessment includes Tier I estimates of environmental concentrations (EECs) in surface water for disulfoton as applied to barley, cotton, potatoes, tobacco, and wheat, using several label application rates and methods. A Tier II analysis was also conducted because many of the estimated concentrations exceeded the EFEDs level-of-concern. Surface and ground-water monitoring data available in the EPA's STORET were also considered, but were considered to be unreliable with too much uncertainty to provide much useful information. The environmental fate data base is not complete. Limited data indicates that the degradates are much more persistent and mobile than parent disulfoton. The degradates, often as toxic as the parent compound, are not considered in this assessment due to lack of environmental fate data.

The GENEEC (Version 1.2; 5/13/95) model was used to estimate environmental concentrations (EECs) in an edge-of-field water bodied. GENEEC is a screening model developed by EFED to be used in Tier I to estimate pesticide concentrations found in surface water for use in ecological risk assessments. The maximum peak, 4-day average, 21-day, and 56-day average concentrations (EECs) were estimated using various combinations of application rates, numbers of applications, and application intervals (Table 2) when applied to barley, cotton, potatoes, tobacco, and spring wheat.

GENEEC is intended to provide an upper-bound concentration value which might be found in ecologically sensitive areas because of pesticide use. GENEEC is a single run-off event model, but can account for spray drift from multiple applications. GENEEC represents a 10-hectare field immediately adjacent to a 1-hectare pond that is 2-meters deep with no outlet. The pond receives spray drift from each application plus the one run-off event. The run-off event transports a maximum of 10% of the pesticide remaining in the top 2.5 cm of soil at the time of the assumed run-off event into the pond. This amount can be reduced through degradation in the field and the soil sorption. Spray drift is determined by method of pesticide application: 0-percent when applied as broadcast, in-furrow, 1% for ground spray, and 5% for aerial spray. Another major limitation in the current GENEEC simulations is that the aquatic (microbial) degradation pathway is not considered due to lack of data. Direct aquatic photolysis is however included.
GENEEC is a screening model used in Tier I (generic high run-off site) to estimate pesticide concentrations found in surface water up to 56 days. Thus, it provides an upper-bound concentration value which might be found in ecologically sensitive areas because of pesticide use. GENEEC is a single run-off event model, but can account for spray drift from multiple

applications. GENEEC simulations were both made with the typical and maximum application rates, maximum number of yearly applications, and the shortest recommended application interval.

A. Limitations of this Modeling Analysis

There are several factors which limit the accuracy and precision of this modeling analysis including the selection of the high-end exposure scenarios, the quality of the fate data, the ability of the model to represent the real world, and the number of years that were modeled. There are additional limitations on the use of these numbers as an estimate of drinking water exposure. Degradation/metabolism products are also not considered due to lack of data.

The quality of the analysis is also directly related to the quality of the chemical and fate parameters available for disulfoton. Acceptable data are available, but rather limited. Data are not available for degradates and the aquatic aerobic metabolism rate was not known, but estimated. The measured aerobic soil metabolism data is limited, but has sufficient sample size to establish an upper 90% confidence bound on the mean of half-lives for the three aerobic soils determined in the laboratory (EFED One-liner, 1997). The use of the 90%-upper bound value may be sufficient to capture the probable estimated environmental concentration when limited data are available.

The GENEEC model itself represents a limitation on the analysis quality. The model was not specifically developed to estimate environmental exposure in drinking water so they may have limitations in their ability to estimate drinking water concentrations. Spray drift reaching the pond is assumed to be 1 percent for ground spray and 5 percent of the application rate for aerial applications. No drift was assumed for broadcast or in-furrow applications. Another limitation is the lack of field data to validate the predicted pesticide run-off. The site represented in GENEEC was selected as a high exposure site, thus, estimated EECs are conservative.

Another important limitation of the Tier I EECs for drinking water exposure estimates is the use of a single 10 hectare drainage basin with a 1 hectare pond. It is unlikely that this small system accurately represents the dynamics in a watershed large enough to support a drinking water utility. It is unlikely that an entire basin, with an adequate size to support a drinking water utility would be planted completely in a single crop or be represented by scenario being modeled. The pesticides would more likely be applied over several days to weeks rather than on a single day. This would reduce the magnitude of the conservative concentration peaks, but also make them broader, reducing the acute exposure, but perhaps increasing the chronic exposure.

B. Modeling Procedure

Environmental fate parameters used in the modeling are summarized in Table 1 . GENEEC was run for a number of crops using different application rates, numbers of applications, application intervals, and methods (Table 2).

Table 1. Disulfoton fate properties and values used in (GENEEC) modeling.

Parameter	Value	Source
Partition Coefficient (Koc)	551.5 (mean of 4)	MRID 43042500
Hydrolysis Half-lives @ pH 4 pH 7 pH 9	1174 days 323 “ 231 “	MRID 143405
Aerobic Soil Half-life	19.39 days (0.03575/d)	Upper 90% confidence bound on the mean of half-lives for the three aerobic soils tested in the laboratory. MRIDs 40042201, 41585101, 43800101
Water Photolysis	3.87 days (pH = 5) (0.179/d)	MRID 40471102
Aerobic Aquatic Half-life	no data	

C. Modeling Results

1. Surface water

The Tier I average estimated environmental concentrations of disulfoton in surface water using the GENEEC screening model results in a minimum peak concentration of 11.2 µg/L for spring wheat in South Dakota and a maximum of 285.4 µg/L for potatoes in Maine. The minimum and maximum 56-day concentrations were 8.7 and 221.2 µg/L for wheat and potatoes, respectively.

Table 2. Surface water concentrations estimates from GENEEC (Version 1.2) for disulfoton.							
Crop	Application Rate/Number/ Interval (lb.ai./ac/#/days)	Drift (%)	Depth Inc.	Peak	4-day	21-day	56-day
Barley	1.005/2/21	0	0.0	28.0	27.5	25.1	21.6
Barley	0.826/2/21	5	0.0	23.0	22.6	20.6	17.8
Cotton	1.009/3/21	0	2.5	13.0	12.7	11.6	10.0
Cotton	3.270/3/21	0	2.5	42.0	41.2	37.6	32.5
Potatoes	4.005/2/14	0	2.5	48.7	47.8	43.7	37.7
Potatoes	9.390/2/14	0	2.5	114.2	112.2	102.4	88.5
Potatoes	4.000/2/14	0	0.0	121.6	119.5	109.0	94.2
Potatoes	9.390/2/14	0	0.0	285.4	280.4	255.9	221.2
Tobacco	8.170/1/0	0	2.5	57.6	56.6	51.6	44.6
Tobacco	4.005/1/0	0	2.5	28.2	27.7	25.3	21.9
Tobacco	16.33/1/0	0	2.5	115.1	113.1	103.2	89.2
Spr. Wheat	1.005/1/0	0	0.0	17.7	17.4	15.9	13.7
Spr. Wheat	0.637/1/0	0	0.0	11.2	11.0	10.1	8.7
Spr. Wheat	0.637/1/0	5	0.0	12.4	12.2	11.1	9.6

The GENEEC estimated disulfoton residue concentrations in surface water appear to be strongly related to application rate, number of applications, application interval, and method of application.

Table 3. Summary of disulfoton detections in STORET.

Type of Water Body	# of Samples	Analytical Method	Disulfoton Concentration[1] (range µg/L)
Stream	1940	39010/39011[2]	0.00-16.00
"	253	81888[3]	0.00-100.00
"	39	82617[4]	0.05-1.00
"	5164	82677[5]	0.00-0.21
Lakes	270	39011	0.01-0.10
"	2	81888	0.05-0.14
"	20	82617	1.00-1.00
"	52	82677	0.00-0.10
Springs	24	39011	0.01-0.10
"	15	81888	0.05-100.00
"	134	82677	0.008-0.060
Reservoirs	2	81888	0.10-0.20
Estuary	4	39011	0.01
"	1	82677	0.02
Canals	2	39011	0.5
"	215	81888	0.03-0.3
Wells	383	39010	1.00-100.00
"	951	39011	0.01-1.00
"	3108	81888	0.00-250.00
"	44	82617	0.03-1.00
"	2559	82677	0.00-0.14

[1] Value reported as "known to be less than reported".

[2] 39010/39011 Flame Photometer Whole Water: disulfoton/disyston

[3] 81888 Disulfoton Whole Water

[4] 82617 Disulfoton Total Recoverable whole water

[5] 82677 Disulfoton "filtered 0.07 um" Total Recoverable whole water

The majority of samples had low levels (<16 µg/L) of disulfoton residues. However, there were indications of some high concentrations (may be a reflection of how the data were reported) as the disulfoton concentrations in the monitoring were not always known. This is because the detection limit was not adequate (extremely high) or specified, and/or the limit of quantification was not stated or extremely high. Disulfoton concentrations were simply given as less than a value. Therefore, considerable uncertainty exists with respect to the monitoring data (especially the STORET data).

ii. Limitations in Monitoring

Monitoring data is limited by the lack of correlation between sampling date and the use patterns of the pesticide within the study's drainage basin. Additionally, the sample locations were not associated with actual drinking water intakes for surface water nor were the monitored wells associated with known ground water drinking water sources. Also, due to many different analytical detection limits, no specified detection limits, or extremely high detection limits, a detailed interpretation of the monitoring data is not always possible.

Appendix IV

Environmental Fate and Chemistry Study Identification

Blumhorst, R.B., and P.Y. Yen. Aerobic Soil Metabolism of [Ethylene-1-^{14}C Disulfoton.] Bayer Report 106944, Study No. D1042103. Unpublished study performed by EPL Bio-Analytical Services., Kansas City, Missouri.

Forbes, A.D. 1988. Uptake, depuration, and bioaccumulation of ^{14}C Di-Syston to bluegill sunfish (Lepomis macrochirus). Performed by Analytical Biochemistry Laboratories; Submitted by Mobay Corp. Received by HED on 2/10/88. MRID# 40471106.

Grace, T.J., K.S. Cain, and J.L. Delk. 1990. Dissipaation of disulfoton in California soils. Performing Laboratory Project IDs: ML022101, 89.023 Plot 24, 89.032 Plot 10, 892010.1-6K, M, 169W. Submitting Laboratory Project ID: D1830089R01. Mobay Report No. 100158. Unpublished study performed by Plant Sciences, Inc., Watsonville, CA; Siemer and Associates,Inc., Fresno, CA and Pharmacology and Toxicology Research Laboratory - West, Richmond, Ca. Submitted by Mobay Corp., Kansas City, Mo.

Graney, R.L., 1989. MRID-43042501. Supplemental submission containing raw data for: uptake, depuration and bioconcentration of ^{14}C Di-syston to bluegill sunfish <u>(Lepomis macrochirus).</u> Mobay Project ID:95078-1. Unpublished study performed by Analytical Biochemistry Lab., Columbia, MO and submitted by Miles, Inc., Kansas City, MO.

Hamman, S.D., G. Olson, J. Howard, and L.J. Lawrence. Volatility of Di-Syston under field conditions. Pharmacology and Toxicology Research Lab., Submitted by Mobay Corp., Received by HED on 2/10/88. Accession No. 40471105.

Hanlon, C.M., and K.S. Cain. 1987. MRID-43060101. Identification of residues from bluegill sunfish exposed to ^{14}C Di-syston. Laboratory Project ID:DI-03-A;Mobay Project ID:95076. Unpublished study performed by Analytical Biochemistry Laboratories , Columbia, MO, and Mobay Corporation, Stilwell, KS. Submitted by Mobay Corp. Stilwell, KS.

Jackson, A.B., L.O. Ruzo, and L.J. Lawrence. Soil surface photolysis of Di-Syston in natural sunlight. Performed by Pharmacology and Toxicology Research Laboratory; Submitted by Mobay Corp., Received by HED on 2/10/88. EPA Accession No. 40471103.

Kasper, A.M., B.A. Shadrick, K.S. Cain, and D.L. Green. 1992. Anaerobic aquatic metabolism of ^{14}C disulfoton. Miles Study No. D1042401; Miles Report No. 103945. Unpublished study performed and submitted by Miles, Inc., Kansas City, MO.

Kesterson, A.B., Ruzo, L.O., and Lawrence, L.J. Photochemical degradation of Di-Syston in aqueous solutions under natural sunlight. Performed by Pharmacology and Toxicology Research Submitted by Mobay Corporation. Received by HED on 2/10/88. EPA Accession No.

40471102.

Leimkuehler, W. M., and J. S. Thornton. 1986. Hydrolysis of DI-Syston in Aqueous Sterile Buffer Solutions. Mobay Report 68943.

Leimkuehler, W.M. & S.K. Valdez. 1989. Soil Adsorption and Desorption of ^{14}C Di-Syston. Unpublished Bayer Report No. 99721, 39 pages. Laboratory Report No. DI182101. MRID #443731-03.

Olson, G.L., and L.J. Lawrence. 1990. Aerobic metabolism of 14C Di-Syston in sandy loam soil. PTRL Report No. 1229; Project No. 320. Unpublished study performed by Pharmacology and Toxicology Research Lab., Lexington, Ky., and submitted by Mobay Corp., Stillwell, KS., MRID-41585101.

Obrist, J.J., 1979. Leaching Characteristics of Aged Di-Syston Soil Residues. Mobay Report No. 67485 -MRID -00145470. Supplemental- No DER, only a memorandum with very little information.

Puhl, R.J. and Hurley.1978. Soil Adsorption and Desorption of Di-Syston- Mobay Report # 66792. No DER was written, but previous reviewer approved the Freundlich K values. MRID #00145469.

Schmidt, J., T.J. Anderson, and D.G. Dyer. 1992. Laboratory volatility of disulfoton from soil. ABC Final Report No.40259. Miles Study No. D1152101. Miles Report No. 103907. Unpublished study performed by ABC Laboratories Inc., Columbia, MO, and submitted by Miles Inc., Kansas City, MO.

APPENDIX V:

ENVIRONMENTAL FATE
DATA REQUIREMENTS FOR
Disulfoton

Chemical No: 032501

Guideline		Use Pattern	Does EPA Have Data to Satisfy the Guideline Req.?	MRID No.	More Data Required?
§158.290 ENVIRONMENTAL FATE					
Degradation Studies-Lab:					
161-1	Hydrolysis	1,2,3	Yes	00143405	No
161-2	Photodegradation In Water	1,2,3	Yes	40471102	No
161-3	Photodegradation On Soil	1,2,3	Yes	40471103	No
Metabolism Studies-Lab:					
162-1	Aerobic Soil	1,2,3	Yes	43800101,40042201,41585101	No
162-2	Anaerobic Soil	1,2,3	No		No
162-3	Anaerobic Aquatic	1,2,3	No	(43042503[2])	Yes
162-4	Aerobic Aquatic	1,2,3	No		No
Mobility Studies:					
163-1	Leaching- Adsorption/Desorp.	1,2,3	Yes	44373103,00145469,43042500,00145470	No
163-2	Volatility (Lab)	1,2,3	Yes	42585802	No
Dissipation Studies-Field:					
164-1	Soil	1,2,3	Yes	43042502	No
Accumulation Studies:					
165-4	In Fish	1,2,3	Partially	43042501,43060101,40471106,40471107	No
Ground Water Monitoring Studies:					
166-1	Small-Scale Prospective				
§158.440 Spray Drift:					
201-1	Droplet Size Spectrum				
202-1	Drift Field Evaluation				

FOOTNOTES:

Appendix VI: Ecological Effects Data Table

Generic Data Requirements for Disulfoton (parent compound) as of 02/02/98

Data Requirement	Composition	Use Pattern[6]	Does EPA Have Data to Satisfy Data Req.	Citation Submitted Under FIFRA 3(c)(2)(B)?	More Data
158.490 Wildlife and Aquatic Organisms					
AVIAN AND MAMMALIAN TESTING					
71-1 Avian oral LD_{50}	TGAI		Yes	25525,00095655, GS0102700,05008363,425858-03	No
71-2 Avian dietary LC_{50}	TGAI		Yes	0094233,00058746,120480	No
71-3 Wild Mammal Toxicity	TGAI		No		No
71-4 Avian Reproduction	TGAI		Yes	43032501, 43032502	No
71-5 Simulated and actual field testing-mammals and birds	TEP		Partially	00095658,00095657	No
AQUATIC ORGANISM TESTING					
72-1 Freshwater fish LC_{50}					
a. Warmwater	TGAI		Yes	40098001,00068268,00003503	No
b. Warmwater	TEP		Yes	229299, 00068268[7]	No
c. Coldwater	TGAI		Yes	40098001,00068268,00003503	No
d. Coldwater	TEP		Yes	00068268[2]	No

[6]A=Terrestrial food, B=Terrestrial feed, C=Terrestrial nonfood, D=Aquatic food, G=Aquatic nonfood, H=Greenhouse food crop, I=Greenhouse nonfood, J=Forestry, K=domestic outdoor, L=Indoor

[7]Submitted study was classified as supplemental and must be repeated in order to fulfill Guidelines requirements

72-2 Freshwater Invertebrate EC_{50}				
a.	TGAI	Yes	00003503,00143401	No
b.	TEP	No		No
72-3 Marine/Estuarine Acute LC_{50}				
a. fish	TGAI	Yes	400716-01	No
b. mollusk	TGAI	Yes	400716-02	No
c. shrimp	TGAI	Yes	400716-03	No
d. fish	TEP	No		No
e. mollusk	TEP	No		No
f. shrimp	TEP	No		No
72-4a Fish early life stage	TGAI (freshwater)	Yes	419358-01	No
	(marine-estuarine)	Yes	426290-01	No
b Aquatic invert. life-cycle	TGAI (freshwater)	Yes	419358-02	No
	(marine-estaurine)	Yes	436109-01	No
72-5 Fish Life Cycle	TGAI (marine-estuarine)	Yes	43960501	No
72-6 Aquatic organism accumulation	TGAI	Yes (See Environmental fate guideline 165-1)		No
72-7 Simulated or actual field testing - aquatic organisms	TEP	Yes		No
158.150 PLANT PROTECTION Nontarget Area Phytotoxicity TIER I				
122-1 Seed germ./ seedling emergence	TGAI	No		No
122-1 Vegetative vigor	TGAI	No		No
122-2 Aquatic plant growth	TGAI	No		No

TIER II				
123-1 Seed germ./ seedling emergence	TGAI	No		No
123-1 Vegetative vigor	TGAI	No		No
123-2 Aquatic plant growth	TGAI	No		No
TIER III				
124-1: Terrestrial plant field testing	TEP	No		No
124-2: Aquatic plant field testing	TEP	No		No
158.590 NONTARGET INSECT TESTING - POLLINATORS				
141-1 Honeybee acute contact toxicity	TGAI	Yes	00066220,05001991,05004151	No
141-2 Honeybee toxicity of residues	TEP	Yes	0163423	No
141-5 Field testing for pollinators	TEP	No		No